Repurposing Geotechnical Data for Energy Transition

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SUMMARY

Petroleum exploration geotechnical disciplines have a documented history of utilizing well managed and curated data to shorten project cycle times, reduce operational risk, and deliver higher quality data driven decisions that optimize asset productivity. Recent initiatives to provide open-source platforms for data visualization and interpretation on the cloud have also made those data sets available to new groups in exploration, as geotechnical experts are re-tasked with exploring for new opportunities in sustainable resources.

Recent case studies show that existing optimum industry best practices for cloud ingestion, enrichment and consumption of digital datasets can be applied to support strategic choices in asset selection and development for sustainable energy resources. The lessons learned from applying principles for making cloud data findable, accessible, interoperable and re-usable are enabling embedded data workflow processes and procedures that deliver value in the area of hydrogen exploration and storage, geothermal, and carbon sequestration projects. The value of digital data in reducing decision latency is easier to measure as monitoring of cloud data storage and delivery metrics becomes more visible. Large digital transformation projects have also led to more executive level representation for digital data managers and their support of data driven decision making in the resource sector. Experience with using digital datasets on the cloud for predictive modelling under uncertainty is being used to evaluate the data necessary to execute strategic selection of sustainable assets, and geoengineering data sets from instrumented facilities are available to enable real-time optimization of existing processing workflows to make them more sustainable.

The re-usability of cloud-based data visualization code means that existing geotechnical data sets can be effectively managed by current technologies and resources, leading to shorter cycle times for return on investment.

Key words: Data Management, Energy Transition, Open Data Platforms

INTRODUCTION

Many regional and international oil and gas organizations are now actively re-branding themselves as energy and technology companies, with common themes such as “we are a data and technology company that finds and produces oil” (Frost and Purdy, 2022), or “we are a global technology company, driving energy innovation for a balanced planet” (Klinge, 2022). This in turn is leading to reuse and repurposing of technical data sets to support technical projects for innovative energy initiatives. The trend can be seen for example in the way that some government regulators and academic consortia have emphasized geospatial and other mapping and modelling data as essential to the technical potential analysis stage of the decision process (Cox et al, 2018). The shift in emphasis can be the result of shareholder activism, increased visibility of ESG (Environmental, Sustainability, and Governance) frameworks, or internal pressure from technical professionals wanting to work on positive solutions for climate and energy sustainability. This means that many digital geoscience technology workers will also need to understand how their skill sets for working with technical data can transition into projects with a lower digital footprint (Harper and Merten, 2021). The incentive is quite clear as surveyed digital strategy professionals across a cross section of producers and service providers have reported large gaps of up to 62% between the relative importance and maturity of disciplines such as data science and analytics (Dickey et al. 2020). What may not be as clear is how the digital data assets that have been traditionally managed by and for exploration and production asset teams can now be re-purposed to support an energy industry in transition. In this paper we will present some recent examples from data management case studies and client interactions that demonstrate the utility of existing digital data sets and the possible challenges of managing, curating, and delivering them to support cleaner energy projects (Saucier, 2021). These examples can provide a basis for updating existing optimum accepted industry practices for data governance and lifecycle data management, with the goal of enhancing competitive advantages of a digitally enabled new energy enterprise. Since some regulatory jurisdictions have specific disincentives for example, for carbon sequestration projects that include enhanced oil recovery (Australian Government, 2022), we will consider skills and competencies required to support the repurposing of existing legacy data sets to support low-carbon projects other than hydrocarbon extraction.

INDUSTRY ACCEPTED OPTIMUM PRACTICES

Many existing oil and gas data management industry accepted optimum processes and technologies have been developed in response to large volumes of geotechnical data and the deployment of cloud computing technology. In recognition of rapid changes in technology, the data management community now favours the use of the term “optimum accepted practices” in place of “best practices”(Baig, 2022). In addition, current definitions of Big Data recognize facets of velocity, variety, veracity and value in addition to just volume (Aliguliyev and Imamverdiyev, 2017). Recognition of these additional facets of Big Data has shifted the emphasis in new energy project data to frameworks that can respond efficiently to rapidly accelerating velocity of data acquisition in a variety of formats, while enabling measures of veracity and the preservation of value for digital datasets. These data sets can reflect literally millions of dollars of acquisition costs (Mohammadpoor and Torabi, 2020) and in some cases represent the last or only data available over geographic areas that are not inaccessible for future geotechnical surveys, due to newly built infrastructure, environmental restrictions, or even changes in terrain. These legacy data sets thus become critical to supporting business decisions around new energy projects, and this has led the professional digital data function to shift from technologies that support data management to those providing true digital data curation (Chelmis et al, 2012).

Data management is focused on the lifecycle of digital geoscience data assets and their movement between applications and data stores, while data curation supports re-usability for new energy projects because it is concerned with the medium to long-term preservation of digital value for the organization. Data curation overlaps with data management in the areas of collection and selection, organization, and presentation of business intelligence to support assets. But embedded data workflows supporting curation are uniquely able to leverage professional subject matter expertise with governance that supports preservation, maintenance and archiving of digital representations of geoscience assets. Digital geoscience curation establishes, maintains and adds value to repositories of digital data in a way that preserves past performance and prepares for present and future uses, such as those in low carbon projects. This requires attention from scientists and subject matter experts who can align with strategic organizational goals (Mixson, 2021) for the reduction of carbon footprints on resource projects. To curate geoscience data properly for new energy projects, the industry will find ways to focus more on the context of how the data was created and in support of which business activities, and how it can be used in the current energy transition environment to deliver value through embedded data workflows (Keyao et al., 2022).

EXAMPLES

Following are examples from the Asia Pacific region that show how existing and new data types can be made available for re-use under the data management principles (Wilkenson et al., 2016) of Findability, Accessibility, Interoperability, and Reusability (FAIR). These principles are increasingly being adopted by both energy operators and government regulators in the region, and can be aligned successfully with existing data governance and curation frameworks. These examples have been collected from working projects in which systems of record have been used to identify and deliver data sets for interpretation and analysis by teams working on low carbon or renewable energy projects.

Well and wellbore analysis data are one of the most widely used data subsets in oil and gas operations. Often well data can be the first indication of potential for renewable resources. It is not surprising then, that one of the first places that experienced data users from exploration or new ventures groups look for business support when evaluating low carbon projects is subsurface well data. One obvious example of re-using existing well data for a new non-hydrocarbon resource is the evaluation hot sedimentary aquifer geothermal systems below existing hydrocarbon production. Pressure/volume/temperature (PVT) and rock mechanics data is often required to be submitted to regulatory agencies where it can be accessed after a prescribed release date. Additional proprietary data can be stored in existing operator databases. In many oil and gas operating companies, well data has one of the highest ranking capability maturity measures of multiple subsurface data objects. In some cases open-file or public domain downhole temperature and reported permeability values from regulatory agency well completion reports can be used to estimate the extent of a geothermal resource (Ballesteros et al., 2020). In these cases issues of data findability and access may have already been addressed by relatively mature data ingestion and curation workflows. Among the outstanding challenges of interoperability for these data can be decisions about how to use existing classification schemes that identify the targets and fluids produced from wells (Zarrouk and McLean, 2019).

Another area of increasing interest is the availability of depleted oil and gas fields for hydrogen storage. Well and core data may be more densely sampled, quality controlled, and available from public sources for existing hydrocarbon reservoirs than for other hydrogen storage targets such as salt caverns or porous water bearing traps (RISC, 2021). This means for existing data sets are available to support geotechnical analysis and interpretation and to support business decisions about using an existing hydrocarbon reservoir as a storage site for hydrogen. In addition, a full history of production pressure behaviour is often accessible when an oil or gas field is nearing the end of its productive life. Specialized reservoir simulation software may be required to use this data to create accurate compositional reservoir simulations for multiple gas phases including the hydrogen, remaining natural gas, CO_2, or nitrogen. However, the embedded data workflows required to deliver this data for both static geologic modelling and dynamic reservoir simulation will be familiar to experienced subsurface data managers, and the data is likely to be already associated with known and stored geospatial data elements such as wells and fields, making it available for map based search and discovery (Figure 1). Challenges for interoperability and reusability of data for hydrogen storage include the applicability of macroscopic gas adsorption data to complex pore networks (Broom et al, 2016)) as these data are unlikely to have been gathered in situ during the hydrocarbon production phase of an existing field. Capturing the uncertainty of lab based measurements in properly curated metadata will be a focus of embedded workflows for reusing these data sets.

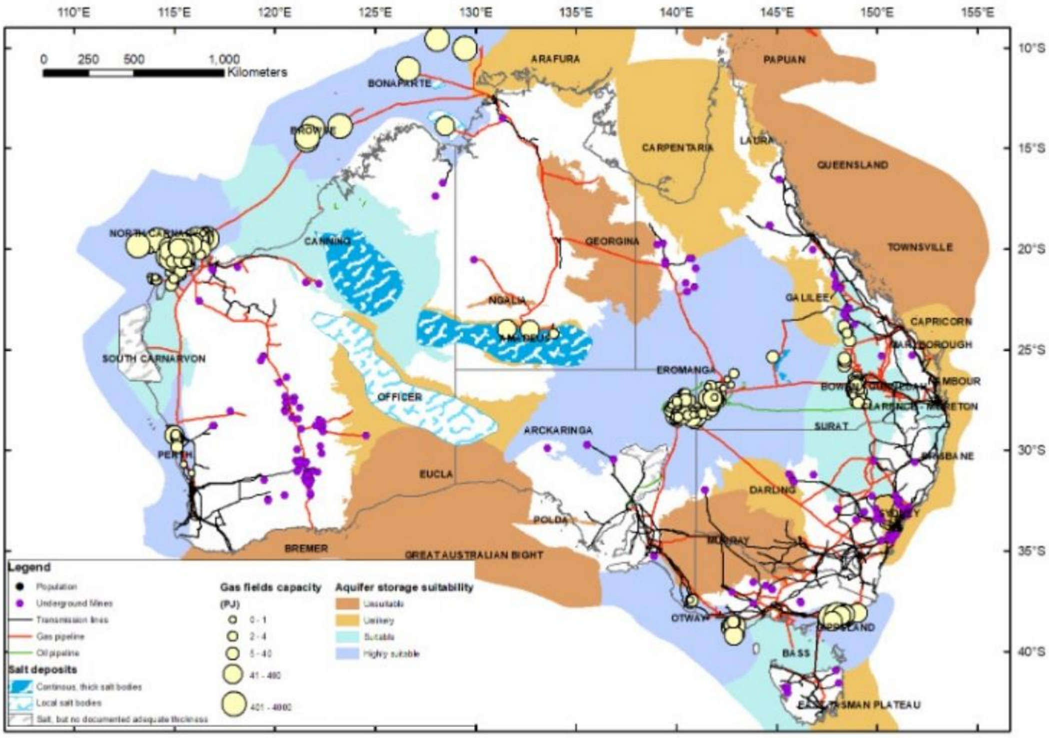

Figure 1. Example of an evaluation of gas field capacity for hydrogen storage compiled from public domain and open-file sources. From Ennis-King, 2021, used by permission.

With interest in hydrogen storage there have also been developments in exploration for natural hydrogen. In this case the data required to evaluate the extent of the probable resource can be even more sparsely sampled, as the quality and consistency of drilling mud gas samples and reporting varies widely. Many oil and gas exploration wells have total depths well short of the fractured basement layers that would be expected to produce commercial quantities of abiogenic gas, so interoperability with gravity and magnetic data that can indicate migration pathways is essential for interpretation and analysis. One notable occurrence of potentially commercial hydrogen production in Australia was noted during a 1931 drilling campaign in limestone, mudstone and red bed clastics. Given the vintage of the data, there are no wireline logs available. At the time, gas shows were recorded in sludge and in samples collected from the bailer at the surface, but to discover this a user would first have to recognize that the original public domain drilling reports were filed under a different well name in the government database. The site visit report does not mention "hydrogen" at all in the searchable text, instead it describes how the slush pump would begin to bubble and how it " resembled a boiling pot with fine spray jumping clear out of the water 5 to 6 inches above the surface" with a "rainbow colouring" and oily scum (the word "oily" was also misspelled in the filed report, which is why traditional text searches had failed to lead to further analysis of this well for some time. The comment that the drillers could "ignite the bubbles with a match and in one instance the flame shot all over the full surface of the slush pump" with an "odour like carbide" were the textual clues that led to further investigation by a team looking at new energy resources in the state. (Boreham et al., 2021). These and some other indications of hydrogen and other gases have only been discovered through manually intensive digitization of legacy handwritten well mudlogging reports, and by enabling data workflows for interoperability of well data with various machine learning and natural language processing algorithms that have been extensively trained to look for possibly associated wording and phrases such as the above.

One of the key areas of lower carbon energy projects in terms of both reusability of existing data sets and in the generation of new data types is carbon capture and underground storage (CCUS), or CO2 sequestration. While existing systems are very likely to have data curation workflows for the input to reservoir models needed for evaluation of storage potential, data management systems will have to be re-designed to accommodate longer retention periods for data required by regulatory monitoring standards. Many regulatory regimes are now establishing the data types that will need to be collected for measurement, monitoring, and verification (MMV) of CO2 storage in subsurface reservoirs. In the case of Asia-Pacific national regulators, some have already described Fundamental Suitability Determinants (FSD) in their legislation that requires a prospect licensee on a CCUS tenement to describe effective sealing features, attributes or mechanisms for the storage formation that enable “permanent storage” without defining if permanent is meant to be on an anthropomorphic or geologic time scale (Bradshaw, 2022). In considering reusability of data, subject matter experts with data governance roles and responsibilities will need to consider that reservoir simulation models for CO2 sequestration can involve time periods of 100’s of years for saturation models and up to 10,000 years for mineralization models. Even more reasonable retention periods based on specified monitoring periods of up to 20 years or a period of time equal to the injection phase of the project will require technology agnostic data storage and retrieval formats to meet these regulatory requirements.

Monitoring plans for underground carbon storage can span a variety of data domains, including surface, near-surface and subsurface, in-well, geochemical and geophysical data objects and definitions (Ghazali et al, 2022). Many of these data types have high densities of collection and sampling, such as soil gas flux for environmental monitoring (Romanaka and Bomse, 2020) or satellite base interferometric synthetic aperture radar (InSAR) data for monitoring terrestrial ground uplift over sequestration sites. Current and potential operators of CCUS projects are contributing to standardized data definitions and metadata reference lists for these data types through open-source data platforms such as the Open Subsurface Data Universe (Apel, 2020). The use of fully instrumented monitor boreholes to track CO2 plume migration in the subsurface has also led to a proliferation of raw data storage, as distributed acoustic sensors (DAS) using fiber optics can generate as much as 10 terabytes of data per day per well. Data management practitioners will need to consider what kind of search and filtering technology can be applied to metadata to most effectively make these data sets findable and accessible. One key strategy is the use of standard data formats such as SEGY for distributed acoustic data (Ellmauthaler et al, 2020) and Energistics PRODML for downhole temperature and strain sensing (Berlang, 2017).

Even data that may have been considered at the time of acquisition to be single purpose and narrowly targeted may also find reusability and application to low-carbon projects. Recent work (Han, C., 2022) has shown, for example, that seismic surveys acquired for exploration work can be reprocessed and used to interpret shallow geohazards during siting of offshore wind farms (Song, G., 2020). Challenges for interoperability in this case center around capturing sufficient metadata to fully understand the positional accuracy of the navigational data in comparison to the spacing requirements of the offshore infrastructure.

CONCLUSIONS

The fact that many of the data objects needed to support low-carbon energy projects are already stored in systems of record for resource organizations means that industry accepted optimum practices for data management and curation can be applied to many of the data types that will be repurposed for the industry’s energy transition. However, new open-source data platforms and ecosystems will also need to be adaptable to larger volumes of data and changes data curation and delivery methodologies. Ideally, technology agnostic principles of data curation will not only allow for efficient re-purposing of existing data, but continuing value retention from new data as it enters embedded data workflows.

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