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IMPLEMENTATION OF DISRUPTIVE TECHNOLOGIES IN SEISMIC INTERPRETATION

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Summary. The modern oil and gas industry is in urgent need of a radical increase in the efficiency of exploration activities to optimise project management. Traditional seismic interpretation technologies have reached their technological limits and are no longer capable of providing the required twofold reduction in desk study timelines while simultaneously improving the quality and detail of geological models. This paper examines an innovative development — SAI-SVision, a full-volume seismic interpretation technology designed to fundamentally transform the approach to organising and executing desk studies. The system's key advantage lies in its ability to rapidly create high-precision structural models. This enables reducing project timelines through the deep parallelisation of technological processes, enhancing the accuracy of integrating heterogeneous data based on a unified structural framework, and optimising decision-making under tight time constraints. The implementation of SAI-SVision delivers a substantial economic effect even at its current stage of development. Further prospects for the technology are linked to its integration directly into the seismic data processing stage, which will significantly improve the quality of depth-velocity models and the signal-to-noise ratio. The final stage of the system's evolution will be the launch of a specialised sedimentation module. This tool will provide the direct transformation of seismic data into a three-dimensional lithofacies grid, creating a reliable foundation for the detailed prediction of fluid saturation and geomechanical characteristics of the section. Thus, the technology elevates the geological modeling process to a qualitatively new, automated level.

Introduction

Conventional seismic interpretation technologies have reached their technological limits and can no longer deliver the efficiency levels required today. Specifically, to optimise project management and ensure timely decision-making, oil companies require a twofold reduction in office-based turnaround time. Simultaneously, this must be achieved alongside an increase in the quality of the resulting geological models. Meeting such demands through the modernisation of standard solutions is unfeasible. The only way forward is the deployment of disruptive innovations. However, even when such technologies are available, their adoption is hindered by several factors. The most formidable challenge is the complexity of integrating breakthrough technologies into production, as the quantum leap in efficiency they provide necessitates a new approach to achieve results: a shift in outdated paradigms and a fundamental modernisation of the entire production process (Fig. 1).

The paper introduces "SAI-SVision," an innovative full-volume seismic interpretation technology that delivers next-generation geological models and completely redefines the office-based interpretation paradigm.

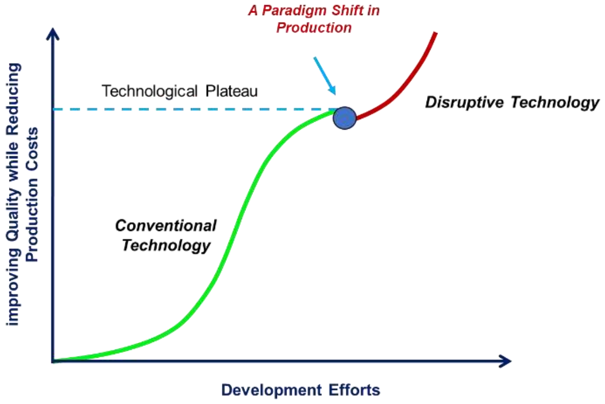

Fig. 1. Disruptive vs. Conventional Technology

Improving seismic interpretation performance via "SAI-SVision" technology

Conventional seismic interpretation is described as an exhausting, iterative sequential process that relies on expert-driven, manual, or semi-automatic tracking of selected horizons from seismic volume. This method is characterised by significant labor intensity, minimal data utilisation (less than 1%), a the high probability of missing prospective targets, substantial uncertainty, and generally low geological model quality, as multiple interpretations can be derived from the same dataset.

At the same time, automating the horizon tracking process fails to either reduce office-based turnaround time or improve the quality of the resulting geological models. This is because automation does not alter the fundamental approach based on analysing a few individual horizons, nor does it eliminate the drawbacks of data underutilisation and the cyclical, iterative nature of the interpretation process.

Full-volume interpretation ensures maximum utilisation of seismic data, which is transformed into a comprehensive model of the medium — the Stratigraphic Cube (SC). The SC is a three-dimensional grid where all nodes are linked by relative depositional ages. The level of detail in the Stratigraphic Cube matches the original seismic data, and its isosurfaces represent chronostratigraphic boundaries.

Analysis of the full-volume model is conducted using the "SVision" methodology. For this purpose, an animated model of sedimentary cover formation is created, typically incorporating several hundred of the most extensive chronostratigraphic boundaries. This model allows tracking changes in paleogeomorphological (in isochrons) and facies (in amplitudes) conditions within the study area, identifying prospective targets across all stratigraphic levels.

The full-volume interpretation approach resolves all the issues inherent in traditional methods, including project timelines, model ambiguity, missed targets, and horizon intersections. Turnaround times are reduced by an order of magnitude, and re-interpretation is no longer required, as the Stratigraphic Cube contains all possible surfaces that can be constructed. Furthermore, all surfaces are mutually consistent, which inherently eliminates intersections. Figure 2 presents examples of missed stratigraphic-type prospects from the standard approach, demonstrating the high efficiency of "SAI-SVision" technology in both marine and continental paleobasin environments.

In carbonate depositional environments, animated models enable the reconstruction of bioherm growth (Fig. 3). This allows for a detailed study of facies settings, including the identification of reef, debris flow (fore-reef), and back-reef lagoon facies.

A new paradigm for organising office-based interpretation workflows

As with any disruptive technology, "SAI-SVision" fundamentally transforms the very paradigm of the production workflow. Under the conventional approach, a sequence of procedures is performed with ambiguous results. This means that it is difficult to assess the economic impact before the work is completed, as the number of identified prospects, their resource potential, and the eventual development costs remain unknown (Kerimov et al., 2019).

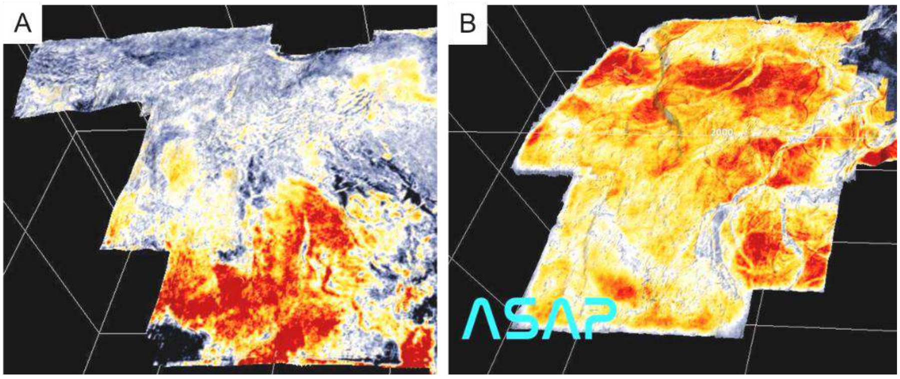

Fig. 2. Stratigraphic traps missed during conventional interpretation. Snapshots from "SVision" animated models: A – Western Siberia, Achimov formation; B – Western Siberia, continental Jurassic

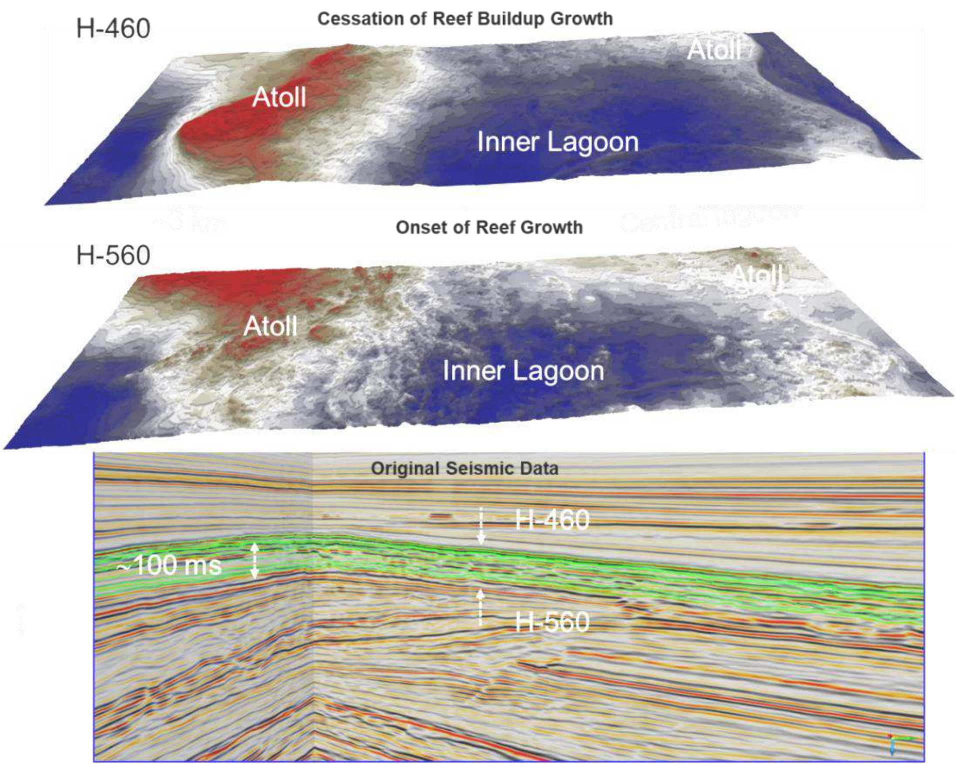

Fig. 3. Reconstruction of reef growth using "SAI-SVision" (North West Shelf, Australia)

In the case of full-volume interpretation, information regarding the presence and scale of all targets – both structural (anticlinal) and stratigraphic – is available within a few days of completing the data processing stage. Notably, one pilot project demonstrated that after eight months of office-based studies using conventional technology, an experienced service company failed to provide any additional geological data beyond what "SAI-SVision" had already delivered within just two days of starting the work (Gorbunov et al., 2021).

Leveraging these and other advantages of this disruptive technology requires a radical reorganisation of the production process at all levels: technical infrastructure, personnel, and regulatory frameworks.

First and foremost, current off-the-shelf interpretation software is fundamentally unsuitable for working with full-volume models (the Stratigraphic Cube), as these tools are designed for analysing individual horizons. Integrating hundreds or thousands of seismic surfaces into a standard analysis workflow is technically unfeasible. Therefore, beyond generating the full-volume model, the "SAI-SVision" technology also provides the capability for its rapid and efficient analysis through the creation of animated models (Guliev et al., 2018a).

On one hand, current technical tools are inapplicable within the framework of the new technology; on the other hand, their existing functionality becomes redundant. Specifically, there is no longer a need for conventional seismic attribute analysis, as detailed paleogeomorphological and lithofacies information is already captured on the Stratigraphic Cube isosurfaces and clearly visualised in "SVision" animated models. Figure 4 illustrates an example of identifying a deep-sea fan in clinoform deposits using "SAI-SVision" compared to the standard seismic attribute analysis methodology (Christensen, 1997, 2003).

Despite the large number of attributes and their combinations used, the maps show only blurred outlines of individual fan elements. Based on these results, it is impossible to assess the true scale of the object (Kerimov et al., 2017a). In contrast, the "SVision" animated model snapshot visualises the target with high resolution. It also clearly shows that a portion of the object extends beyond the study area (Kerimov et al., 2014; Kerimov et al., 2016a).

The implementation of this disruptive technology will also require specialists to significantly transform their professional skill sets. Some skills will become redundant (e.g., horizon correlation), while new ones must be acquired. The conventional geological modeling workflow is fragmented into separate disciplines: interpretation, well-to-seismic ties, inter-well correlation, attribute analysis, petrophysics, etc. (Kerimov et al., 2018). In this siloed approach, each specialist starts working with their own data type, which drastically reduces overall team efficiency; significant time is lost on subsequent coordination and the alignment of individual results, leading to the previously mentioned cyclical and iterative nature of the process (Kerimov et al., 2017b; Guliev et al., 2018b).

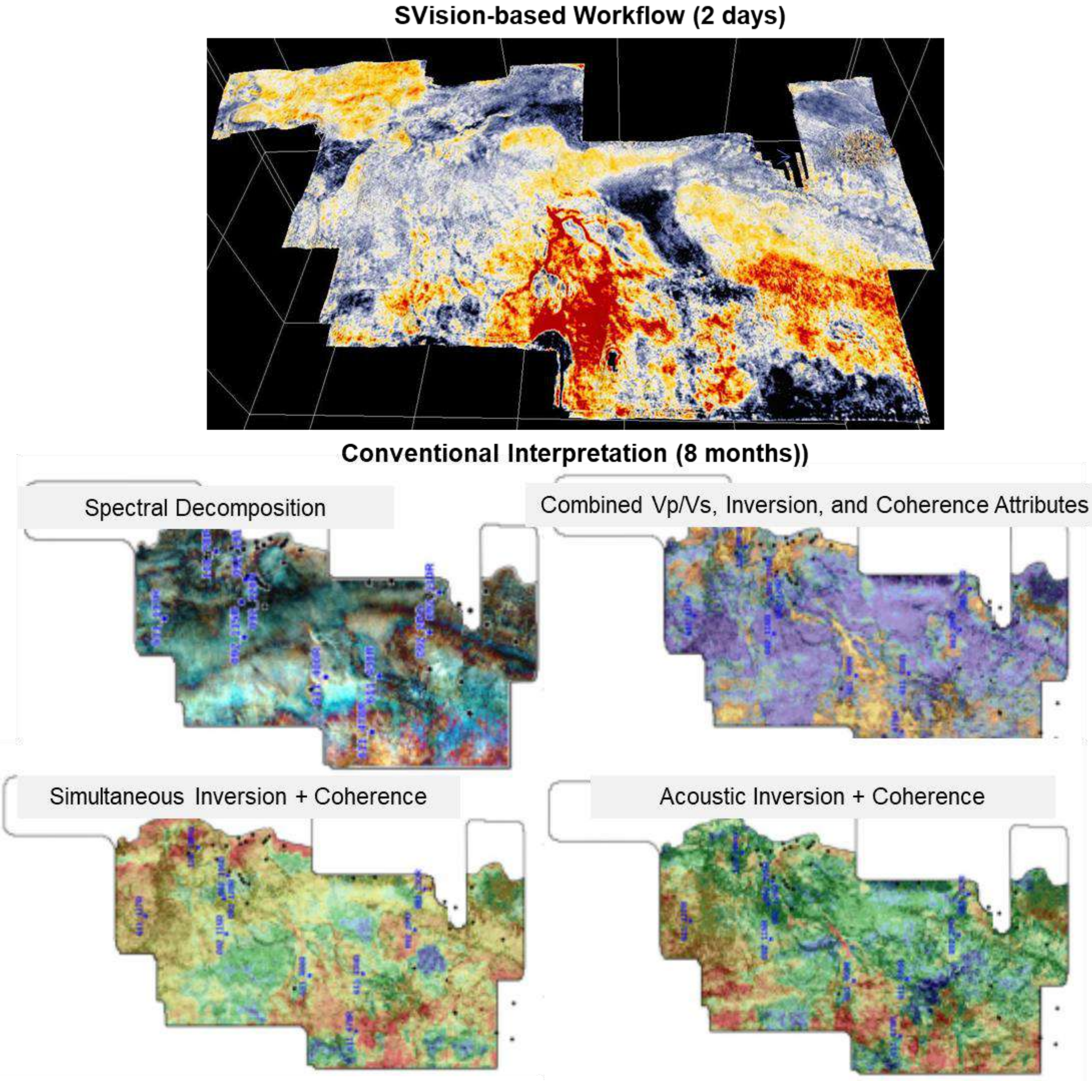

Fig. 4. Comparison of stratigraphic trap identification: "SAI-SVision" vs. conventional seismic attribute analysis

Under the new technology, team collaboration is organised more efficiently (Fig. 5). This is achieved because, once the Stratigraphic Cube is generated and the "SVision" animated models are collectively analysed, all specialists work simultaneously on a unified geological model concept, each within their own discipline.

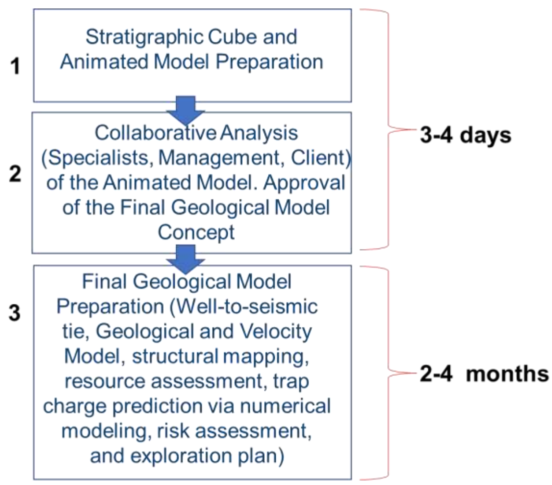

Fig. 5. Key stages of the "SAI-SVision" technology workflow

This approach offers an additional advantage by facilitating management involvement in the geological modeling process at the early stages of the project. This allows project optimisation based on animated model analysis, resource reallocation, and overall more effective project management (Gorbunov, Lavrenova, 2018). For instance, in current practice, the technical assignment (Scope of Work) for office-based studies is formulated before the work even begins. This is inefficient, as the geological features of the target remain unknown, making it generally impossible to select an optimal set of analytical methods. Consequently, some methods prescribed in the SOW prove ineffective, and the set objectives are not met (Lapidus et al., 2018), leading to additional work, budget overruns, and project delays. With "SVision" technology, the optimal list of methods is determined based on the results of animated model analysis (Rachinsky, Kerimov, 2015; Kerimov et al., 2015a).

The ability to parallelise the interpretation process once, the structural framework (the Stratigraphic Cube) is established which allows the integration of multiple independent methods without increasing office-based turnaround time (Kerimov, Gorbunov et al., 2015; Kerimov et al., 2015b; 2015c). This results in more informative geological models. For example, by incorporating numerical modeling, it is possible to produce a fluid saturation map upon completion of the office-based studies, rather than a conventional reservoir map (Fig. 6).

Current realities are such that the existing regulatory framework – including standard technical assignment (SOW) practices, strictly regulated requirements for contractor personnel, mandated software and hardware, and procurement procedures – effectively prevents companies from adopting new technologies and increasing their operational efficiency. Consequently, a transformation of this sector of production activity is also essential (Kerimov et al., 2020; Kerimov et al., 2016b; Kerimov et al., 2015d).

Conclusions

By reorganising existing production processes, a substantial economic impact from "SAI-SVision" technology can be achieved even at its current stage of development. Rapid structural model generation reduces turnaround times through workflow parallelisation, enables the integration of a wider range of multidisciplinary methods, and increases overall interpretation efficiency by utilising a unified structural framework.

Further development of the technology toward its application during the seismic data processing stage will improve the quality of the depth-velocity model and the signal-to-noise ratio, ensuring even greater reductions in office-based turnaround time.

The subsequent development and integration of the "SAI-SVision" sedimentation module will allow the direct transformation of seismic data into a 3D lithofacies grid. This will provide the foundation for high-resolution fluid saturation prediction, geomechanical characterisation of the section, and advanced reservoir modeling.

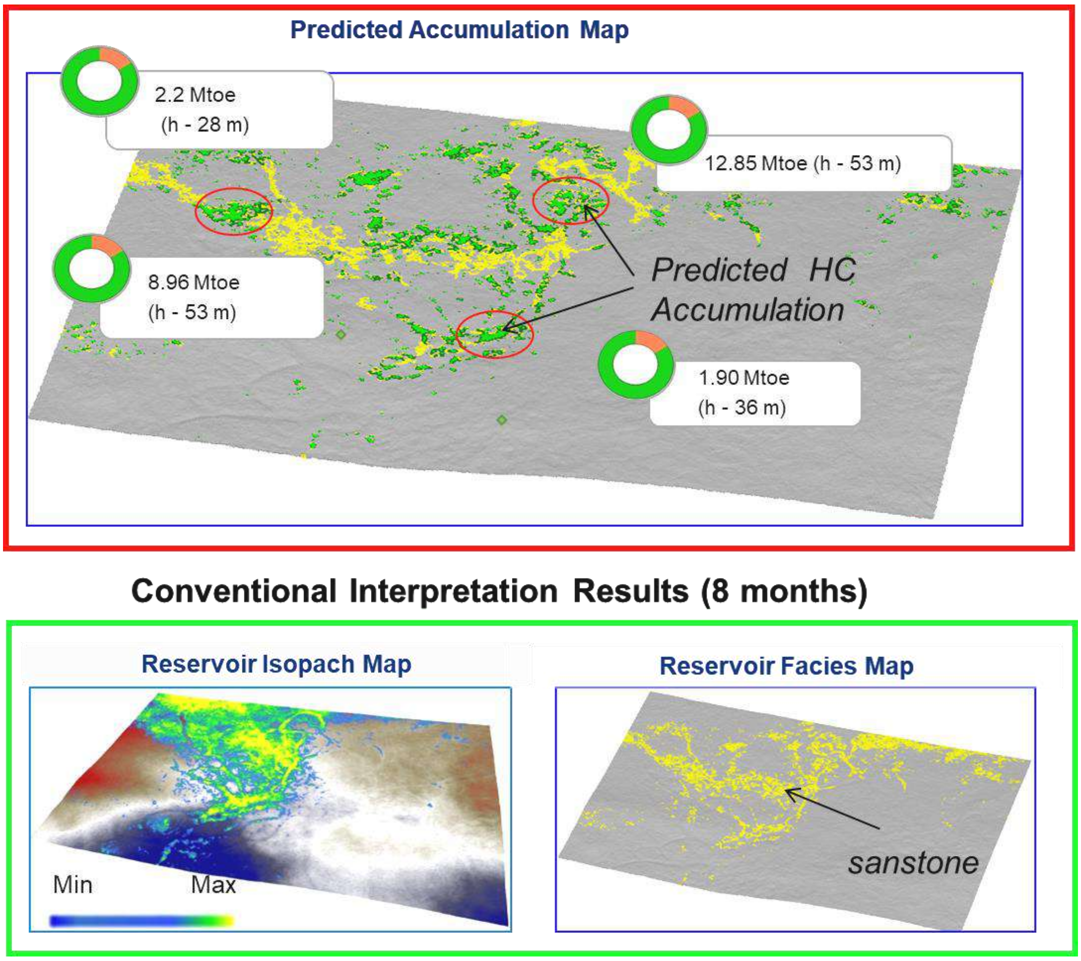

Fig. 6. Enhancement of geological model quality using "SAI-SVision" through interpretation workflow parallelisation and integration of numerical modeling. Project survey data (Shelf, Australia): survey area – 600 sq. km; record length – 5 s; number of wells – 4. Objective: Assessment of hydrocarbon potential in channel-fill deposits

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ВНЕДРЕНИЕ ИННОВАЦИОННЫХ ТЕХНОЛОГИЙ В СЕЙСМИЧЕСКОЙ ИНТЕРПРЕТАЦИИ

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Резюме. Современная нефтегазовая отрасль остро нуждается в радикальном повышении эффективности разведочных работ для оптимизации управления проектами. Традиционные технологии сейсмической интерпретации достигли своих технологических пределов и больше не способны обеспечить необходимое двукратное сокращение сроков кабинетных исследований при одновременном улучшении качества и детализации геологических моделей. Решение этой масштабной задачи невозможно путем частичной модернизации стандартных инструментов; требуется стратегический переход к инновационным, прорывным технологиям и полная замена устаревших производственных парадигм. В данной статье рассматривается инновационная разработка — технология полнообъемной сейсмической интерпретации «SAI-SVision», призванная фундаментально изменить подход к организации и выполнению камеральных работ. Ключевое преимущество системы заключается в возможности оперативного создания высокоточных структурных моделей. Это позволяет сокращать сроки проектирования за счет глубокого распараллеливания технологических процессов, повышать точность комплексирования разнородных данных на базе единой структурной основы и оптимизировать принятие решений в условиях жестких временных ограничений. Внедрение «SAI-SVision» обеспечивает существенный экономический эффект уже на текущем уровне её развития. Дальнейшие перспективы технологии связаны с её интеграцией непосредственно в процесс обработки сейсмических данных, что позволит значительно улучшить качество глубинно-скоростных моделей и соотношение «сигнал-шум». Финальным этапом эволюции системы станет запуск специализированного седиментационного модуля. Данный инструмент обеспечит прямую трансформацию сейсмических данных в трехмерный грид литофаций, создавая надежный фундамент для детального прогнозирования флюидонасыщения и геомеханических характеристик разреза. Таким образом, технология переводит процесс геологического моделирования на качественно новый, автоматизированный уровень.

Ключевые слова: *прорывные технологии, сейсмическая интерпретация, геологическая модель, стратиграфия, углеводороды, стратиграфические ловушки, технология SAI-SVision*

SEYSMİK İNTERPRETASİYA SAHƏSİNDƏ İNNOVATİV TEXNOLOGİYALARIN TƏTBİQİ

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Xülasə. Müasir neft və qaz sənayesi layihə idarəetməsini optimallaşdırmaq üçün kəşfiyyat əməliyyatlarının səmərəliliyini kökündən artırmalıdır. Ənənəvi seysmik şərh texnologiyaları texnoloji hədlərinə çatıb və artıq masaüstü tədqiqatların tələb olunan yarıya endirilməsini təmin etməklə yanaşı, geoloji modellərin keyfiyyətini və detallarını da yaxşılaşdıra bilmir. Bu iddialı vəzifə standart alətlərin qismən modernləşdirilməsi yolu ilə həll edilə bilməz; innovativ, irəliləyişli texnologiyalara strateji keçid və köhnəlmiş istehsal paradiqmalarının tamamilə dəyişdirilməsi tələb olunur. Bu məqalədə innovativ bir inkişaf — masaüstü işlərin təşkili və yerinə yetirilməsinə yanaşmanı kökündən dəyişdirmək üçün hazırlanmış tammiqyaslı seysmik şərh texnologiyası olan SAI-SVision müzakirə olunur. Sistemin əsas üstünlüyü yüksək dəqiqlikli struktur modelləri tez bir zamanda yaratmaq qabiliyyətidir. Bu, texnoloji proseslərin geniş paralelləşdirilməsi yolu ilə dizayn müddətini azaldır, fərqli məlumatların vahid struktur əsasda inteqrasiyasının dəqiqliyini artırır və sıx vaxt məhdudiyyətləri altında qərar qəbuletməni optimallaşdırır. SAI-SVision-ın tətbiqi hətta hazırkı inkişaf səviyyəsində belə əhəmiyyətli iqtisadi fayda təmin edir. Texnologiyanın gələcək perspektivləri onun dərinlik-sürət modellərinin keyfiyyətini və siqnal-səs-küy nisbətini əhəmiyyətli dərəcədə yaxşılaşdıracaq seysmik məlumatların emalına birbaşa inteqrasiyasındadır. Sistemin təkamülünün son mərhələsi ixtisaslaşmış çöküntü modulunun işə salınması olacaq. Bu alət seysmik məlumatların birbaşa 3D litofasiya şəbəkəsinə çevrilməsinə imkan verəcək və maye doymasının və yeraltının geomekanik xüsusiyyətlərinin ətraflı proqnozlaşdırılması üçün etibarlı bir təməl yaradacaq. Beləliklə, texnologiya geoloji modelləşdirməni keyfiyyətcə yeni, avtomatlaşdırılmış səviyyəyə qaldırır.

Açar sözlər: *qabaqcıl texnologiyalar, seysmik interpretasiya, geoloji model, stratiqrafiya, karbohidrogenlər, stratiqrafik tələlər, SAI-SVision texnologiyası*