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«ЛУКОЙЛ – Инженерные Навыки и Компетенции»
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Практика внедрения концепции «Lean Management» в ООО «ЛИНК»

Статья посвящена опыту применения модели «7S Lean Management» в ООО «ЛИНК». Представлен анализ базовых управленческих практик, используемых в промышленном инжиниринге, рассматривается концепция бережливого производства в инжиниринговом производственно-сервисном центре. Особое внимание уделено ключевым целям и стратегическим притязаниям компании от использования стандартизированных практик бережливого производства, приведены примеры проектов в этой области.

Ключевые слова: инжиниринг, бережливое производство, управленческие практики.

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Practical Issues of Implementation of the "Lean Management" Concept at LINK LLC

This article provides the analysis of using the concept of lean production concept practice in the Engineering Production and Service Center of LINK LLC. The basic management practice used in industrial engineering has been presented and some particular features of LINK LLC have been described. Taking into account these particular features, the "7S Lean Management" model, which is used in the company, has been provided. The major goals and strategic claims based on use of standardized lean production practice at LINK LLC have been described, as well as examples of projects in this area have been provided.

Key words: *engineering, lean production, management practice.*

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Современные технологии и тренды рынка вторичных полимеров

За последние 5 лет появилось значительное количество технологий переработки пластиковых отходов в нефтехимические продукты с высокой добавленной стоимостью: пластиковые отходы могут быть возвращены для переработки в нефтехимические продукты с добавленной стоимостью, включая ароматические углеводороды, водород, синтез-газ и биосырье, с использованием различных технологий включая термохимическую, каталитическую конверсию и химолиз. В статье рассмотрены перспективы рынка переработки полимеров и производства вторичных полимеров, основы регулирования и стимулирования, представлен опыт «ЛИНК» (производственно-сервисный центр Компании «ЛУКОЙЛ») по теме переработки полимерных отходов и оценке углеродного следа.

Ключевые слова: полимерные отходы, вторичные пластики, оценка жизненного цикла, углеродный след, циркулярная экономика, рециклинг, переработка полимеров.

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Recycled Polymers: Market Trends, Regulation, Advanced Technology Routes

Over the last 5 years, a significant number of technologies for recycling plastic waste into petrochemical products with high added value have emerged: plastic waste can be recovered for processing into petrochemical products with added value, including aromatic hydrocarbons, hydrogen, synthesis gas and bio feedstock, using various technologies including thermochemical, catalytic conversion and chemolysis. The article discusses the prospects of the polymer recycling market and production of secondary polymers, basics of regulation and stimulation, and overviews the expertise of LINK (LUKOIL's production and service center) on the topic of polymer waste recycling and carbon footprint assessment.

Key words: *polymer waste, secondary plastics, lifecycle assessment, carbon footprint, circular economy, recycling, polymer recycling.*

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Направления снижения углеродного следа продукции нефтехимической промышленности — на пути к "зеленой химии"

В статье рассмотрены направления химической утилизации диоксида углерода, которые могут использоваться в нефте- и химической промышленности для сокращения выбросов CO_2 и углеродного следа продукции на определенных этапах жизненного цикла, как апробированные и применяемые в промышленном масштабе, так и находящиеся в стадии проработки и пилотных испытаний. Сделаны выводы о перспективах разработки соответствующих технологий с целью декарбонизации и устойчивого развития, определены факторы, имеющие значение для выбора направления производства «зеленой» продукции с использованием CO_2 или других вариантов его утилизации.

Ключевые слова: зеленая химия, удобрения, химическая продукция, углеродный след, циркулярная экономика, метанол, синтетические топлива.

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Technology Routes for Reducing the Carbon Footprint of Petrochemical Products – a Pathway to Green Chemicals

The authors review the routes for chemical utilization of carbon dioxide, which can be used in the oil and chemical industry to reduce CO_2 emissions in terms of volumes avoided and the carbon footprint of products at certain stages of the lifecycle – both that have industry-scale applications, and those in the stage of development and pilot testing. Based on this technology review, conclusions are drawn about the prospects of certain technologies within the country for the purposes of decarbonization and sustainable development, and factors relevant to the choice of the direction of green products manufacture using CO_2 or other options for its utilization are identified.

Key words: *green chemistry, fertilizers, chemical products, carbon footprint, circular economy, methanol, synthetic fuels.*

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Варианты эффективного применения побочных продуктов нефтепереработки и нефтехимии в процессе флотации труднообогатимых и высокозольных каменных углей

В статье рассмотрены вопросы по разработке эффективных реагентов для флотации труднообогатимого и высокозольного угля с высоким содержанием фюзеновых элементов. Представлены данные ситового и фракционного составов, петрографического и рефректограмного анализов исследуемого угля, а также зольности. Получение концентратов при флотации с зольностью, удовлетворяющей коксохимическое производство с применением известных флотореагентов затруднительно. Изучены реагентные режимы с применением флотореагентов на основе полупродуктов нефтехимии и нефтепереработки, которые показывают высокую эффективность при флотации труднообогатимых и высокозольных углей. Представлены научные обоснования их эффективности.

Ключевые слова: высокозольный уголь, флотация, реагент-собиратель, кубовый остаток ректификации этилбензола, легкий газойль каталитического крекинга, реагентный режим.

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Effective Application Options By-Products of Oil Refining and Petrochemistry in the Process of Flotation of Hard-To-Enrich and High-Ash Coal

The article deals with the development of effective reagents for flotation of hard-to-enrich and high-ash coal with a high content of fusene elements. The results of studies of the physicochemical properties of this coal are presented: sieve and fractional compositions, petrographic and refrectogram analyses of the coal under study, as well as ash content. It is difficult to obtain concentrates during flotation with ash content satisfying coke chemical production using known flotation reagents. Reagent regimes with the use of flotation reagents based on petrochemicals and oil refining intermediates have been studied, which show high efficiency in flotation of hard-to-enrich and high-ash coals. Scientific substantiations of their effectiveness are presented.

Key words: *high-ash coal, flotation reagent-collector, VAT residue of ethylbenzene, light catalytic cracking gas oil, agent mode.*

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Исследование каталитического крекинга продуктов деасфальтизации гудрона

В рамках проведения исследований по расширению сырьевой базы процесса каталитического крекинга в псевдоожиженном слое (FCC) получен продукт деасфальтизации гудрона н-пентаном. Выполнен анализ

свойств деасфальтизата: фракционный и групповой углеводородный состав, плотность, коксуемость по Конрадсону, содержание серы, азота, ванадия и никеля. Для сравнения выполнена оценка по указанным параметрам промышленного продукта пропановой деасфальтизации. Для обоих продуктов как для потенциальных компонентов сырья процесса FCC осуществлен процесса каталитического крекинга в псевдоожиженном слое. Установлены показатели степени конверсии и выходов газообразных и жидких продуктов превращения. Показано, что пропановый деасфальтизат по своим характеристикам является перспективным сырьем процесса FCC. Продукт деасфальтизации гудрона н-пентаном также может найти свое применение в качестве сырьевого компонента процесса FCC, однако его целесообразно применять в смеси с традиционными видами сырья, такими как вакуумный газойль.
Ключевые слова: каталитический крекинг, FCC, конверсия, деасфальтизат.

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Study of FCC of the Vacuum Residue Deasphalting Products
Within the frames of research on expanding of the Fluid Catalytic Cracking Process (FCC) feedstock base, a product of vacuum residue de-asphalting using n-pentane has been obtained. The properties of deasphalted oil have been analyzed: fractional and hydrocarbon content, density, Conradson coking capacity, sulfur, nitrogen, vanadium and nickel content. For comparison, the estimation of the industrial product of propane de-asphalting has been performed according to the specified parameters. Both products as potential components of the FCC feedstock have been processed in a fluidized bed catalytic cracking unit. Indicators of the degree of conversion and yields of gaseous and liquid transformation products have been established. It is proved that propane deasphalted oil by its characteristics is a promising feedstock for the fluid catalytic cracking process. The product of vacuum residue de-asphalting with n-pentane can also be used as a feedstock component of the FCC process, but it is advisable to use it in a mixture with traditional types of feedstock such as vacuum gas oil.
Key words: *catalytic cracking, FCC, conversion, deasphalted oil.*

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Моделирование вязкости смесей в системах оптимального планирования
В работе приведены результаты экспериментальных измерений кинематической вязкости смесей компонентов переработки. Исследована взаимосвязь вязкости и плотности смеси. Разработана методика корректировки параметров модели расчета вязкости в системах оптимального планирования с использованием углового косинусного расстояния. Представлены численные эксперименты на модели оптимального планирования нефтеперерабатывающих заводов.
Ключевые слова*:* вязкость, моделирование, линейное программирование, нефтепереработка.

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Viscosity Mixtures Modeling in Optimal Planning Systems

The paper deals with experimental measurements results of kinematic viscosity of processing components mixtures with a focus on the relationship between viscosity and density of a hydrocarbons mixture. It has been developed a technique for adjusting the parameters of the viscosity calculation model in optimal planning systems using the angular cosine distance. Numerical experiments on a refinery optimal planning model are presented.

Key words: *viscosity, modeling, linear programming, refinery.*

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Актуальность оптимизации процессов смешения и переработки мазутов
на нефтеперерабатывающих заводах России

В статье рассмотрены вопросы смешения мазутов на российских НПЗ. Представлены основные марки мазутов, описаны процессы смешения и приготовления мазутов на НПЗ. Обозначено сохранение потребности в низкосернистых мазутах и актуальность оптимизации процессов его смешения. Изучены рыночные индикаторы на мазуты, перспективы спроса на внутреннем рынке и на экспорт в связи с экологическими ограничениями MARPOL и санкционными экономическими барьерами. Отмечена важность автоматизации и цифровизации процесса смешения мазутов в рамках реализации проектов оптимального календарного смешения нефтепродуктов.

Ключевые слова: мазут, нефтеперерабатывающий завод, оптимизация, сероводород,
озонолиз, календарное планирование.

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The Relevance of Optimizing the Processes of Mixing and Processing
of Fuel Oil at Russian Refineries

The article discusses the issues of mixing fuel oil at domestic refineries. The main brands of fuel oil are presented, the processes of mixing and preparation of fuel oil at refineries are described. The preservation of the need for low-sulfur fuel oil and the relevance of optimizing its mixing processes are indicated. Market indicators for fuel oil, prospects for demand in the domestic market and for exports due to MARPOL environmental restrictions and economic sanctions

barriers were studied. The importance of automation and digitalization of the process of mixing fuel oil in the framework of the implementation of projects of optimal calendar mixing of petroleum products is noted.

Key words: *fuel oil, refinery, optimization, hydrogen sulfide, ozonolysis, calendar planning.*

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Применение SLM-технологии для изготовления деталей оборудования нефтеперерабатывающих предприятий

В статье представлены результаты работы по реинжинирингу ответственных деталей импортного оборудования, включающий выбор деталей, оптимально подходящих для изготовления методом аддитивных технологий, с использованием расчетов коэффициента аддитивности, создание 3D-моделей и конструкторской документации, материальное исполнение деталей, построение методом селективного лазерного плавления металлов (SLM). Приведены результаты анализа структуры по различным осям построения, механических характеристик и твердости материала, полученного методом аддитивных технологий. При исследовании структуры и прочностных характеристик выявлена анизотропия, связанная с послойным выращиванием детали. Основным недостатком структуры, полученной методом SLM, является пористость, но при отработанных режимах печати данный параметр можно контролировать и гарантировать качественную структуру с минимальным размером пористости (до 2 мкм).

Ключевые слова: аддитивные технологии, 3D-печать, селективное лазерное плавление металлов, сталь, твердость, механические характеристики.

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Application of SLM Technology for Manufacturing of Equipment Parts for Oil Refineries

The paper presents the results of work on re-engineering of safety critical parts of imported equipment, including the selection of parts optimally suited for manufacturing by the additive technology (AT) method using additivity coefficient calculations, creation of 3D-models and design documentation, material execution of parts, construction by the selective laser melting of metals (SLM) method. The paper comprises of analysis of the structure on different axes of construction, mechanical characteristics and hardness of the material obtained by the AT method. In the study

of the structure and strength characteristics, anisotropy associated with layer-by-layer growth of the part is revealed. The main disadvantage of the structure obtained by the SLM method is porosity, but with the developed printing modes, this parameter can be controlled and a quality structure with a minimum porosity size (up to 2 μm) can be guaranteed.
Key words: *additive technologies, 3D printing, selective laser melting of metals, steel, hardness, mechanical characteristics.*

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Моделирование параметров качества
нефтяных битумов с использованием алгоритмов машинного обучения

В работе рассмотрены подходы, принципы и результаты моделирования параметров качества нефтяных битумов с использованием алгоритмов машинного обучения на основе рекуррентных нейронных сетей. Показано, что для процессов нефтепереработки возможно использование в практических целях алгоритмов машинного обучения. Рассмотрены различные проблемы при обработке данных, отбор переменных и выбор архитектуры нейронной сети для решения конкретной задачи. Обозначены дальнейшие направления исследования.
Ключевые слова: нефтебитум, моделирование, машинное обучение, рекуррентные нейронные сети, анализ данных.

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Modeling of Bitumen Quality Parameters Using Machine Learning Algorithms

The paper considers approaches, principles, and results of modeling the quality parameters of petroleum bitumen using machine-learning algorithms based on recurrent neural networks. It is shown that for oil refining processes it is possible to use machine-learning algorithms for practical purposes. Various problems in data processing, the selection of variables and the choice of neural network architecture for solving a specific problem are considered. Further directions of research are indicated.
Key words: *petroleum bitumen, modeling, machine learning, recurrent neural networks, data analysis.*

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Характеристика асфальтеновых фракций, ответственных за образование стабильных водонефтяных эмульсий

Образование стабильных водонефтяных эмульсий объясняется формированием на границе раздела нефть/вода бронирующих слоев, обладающих механической прочностью и препятствующих коалесценции капель воды в нефти. На примере модельных водонефтяных эмульсий, образованных при смешении асфальтеновых толуольных и гептольных растворов с дистиллированной водой, показано, что стабильность водонефтяных эмульсий определяется двумя фракциями асфальтенов: растворимой фракцией, обогащенной сложноэфирными фрагментами, и фракцией, склонной к формированию агрегатов. Поверхностно-активные свойства первой фракции позволяют формировать на границе раздела нефть/вода тонкую оболочку с низкой механической прочностью. Асфальтеновые агрегаты, адсорбируясь на эту тонкую оболочку и уплотняясь со временем, придают жесткость и механическую прочность межфазному слою на границе раздела нефть/вода.

Ключевые слова: *асфальтены, фракции, водонефтяные эмульсии, стабильность, механическая прочность.*

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Characteristics of Asphaltene Fractions Responsible
for the Formation of Stable Water-Oil Emulsions

Stable water-oil emulsions are formed due to the strong armor layer at the oil/water interface able to prevent the coalescence of water droplets in oil. The stability of water-oil emulsions obtained by mixing solutions of asphaltene in toluene and in heptol (a mixture of n-heptanol and toluene) with distilled water was found to be a function of two asphaltene fractions, namely, a fraction soluble in heptol enriched with ester fragments and a fraction tending to form aggregates in heptol. The surfactant properties of the first fraction permit the formation of a thin shell with low mechanical strength at the oil/water interface. The asphaltene aggregates adsorbed onto this thin shell are compacted over time, imparting rigidity and mechanical strength to the oil/water interface layer.

Keywords: *asphaltenes, asphaltene aggregates, water-oil emulsions, stability of water-oil emulsions.*

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Оптимальное проектирование адсорберов для разделения газовых смесей

Работа посвящена исследованию и оптимальному проектированию разделения *газовых смесей(CO_2/CH_4 и CO_2/N_2) адсорбционным методом. В качестве адсорбентов использованы синтетические цеолиты NaX. Использованы бинарные модельные смеси газов: CO_2 – 50%,CH_4 – 50% и N_2 – 50%, CH_4 – 50% объем. Определены коэффициенты диффузии. Эксперименты проводилась при температуре 295 К. Разработана полная математическая модель процесса адсорбции.*

Ключевые слова: *газовые смеси, адсорбер, неподвижный слой, массообмен, коэффициенты диффузии, математическая модель.*

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Optimal Design of Adsorbers for Separation of Gas Mixtures

The work is devoted to the study and optimal design of the separation of gas mixtures (CO_2/CH_4 and CO_2/N_2) by the adsorption method. Synthetic zeolites NaX were used as adsorbents. Binary model mixtures of the gases were used: CO_2 50%, CH_4 50%, and N_2 50%, CH_4 50% by volume. The diffusion coefficients were determined. The experiments were carried out at a temperature of 295 K. A complete mathematical model of the adsorption process was developed.

Keywords: *gas mixtures, adsorber, fixed layer, mass exchange, diffusion coefficients, mathematical model.*

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Study on the Geochemical Genesis and Differences of Ordovician Oil and Gas Reservoirs

The study of fluid inclusions in petroliferous basins is an effective method to understand hydrocarbon migration and accumulation. In this paper, the fluid inclusions in the Ordovician carbonate rock samples

taken from the TS3, TP18, YQ8 and YJ2-3 wells in Tahe Oilfield are analyzed by experiments, the purpose is to explore the accumulation period of the Ordovician oil and gas reservoirs in the Tahe area and the reasons for the differences between different blocks.The results show that the Ordovician Yingshan Formation and the Yifangfang Formation in the Tahe area are rich in fluid inclusions, and there are only a single phase of oil, gas and brine in the phase. There are also two phases of oil, gas and water mixed with each other. According to the fluorescence characteristics and homogenization temperature of hydrocarbon inclusions, combined with the burial history-thermal evolution history of the study area, it is determined that the Tahe oil and gas reservoir is filled in the fourth stage, in the middle of the Caledonian period (454-446 Ma), and in the late Hercynian-Indosinian period (255-217 Ma), late Yanshanian period(143-99 Ma), Himalayan period (25-5 Ma).Among them, the middle of Caledon is mainly filled with low-mature oil, with a small amount of mature oil; the late high-mature oil in the late Hercynian is filled with some mature oil; the late Yanshan is mainly filled with high mature oil; during the Himalayan period, as the depth of burial continues to increase, the cracking of the accumulated hydrocarbons has occurred, mainly the migration of gas hydrocarbons. The four wells selected in this study belong to different tectonic units, after analysis, the author believes that the difference between single wells is on the one hand the influence of hydrocarbon thermal evolution and the other is influenced by tectonic movement.

Keywords: *Ordovician, fluid inclusions, hydrocarbon charging event, accumulation period.*

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Experimental Study on Damage and Control Methods
of Fracturing Fluid Retention to Tight Shale Matrix

The tight shale matrix has the structural characteristics of low porosity and low permeability. It is easy to cause water sensitivity damage, water lock damage and solid phase damage during fracturing, which greatly affects the gas reservoir transportation process of core. At the same time, fracturing fluid will invade the reservoir matrix, causing permeability damage and reducing gas production efficiency. This study analyzes the process and mechanism of fracturing fluid damage to shale matrix in the process of fracturing fluid retention, and proposes fracturing fluid damage control methods. Taking a tight sandstone reservoir in the ZJ block in South Sichuan as the research object, the mineral type, viscosity content and various physical parameters of shale gas reservoir are analyzed, and the quantitative index of fracturing fluid damage index is calculated. Using HPG as the precursor fluid, KW-1 and KDF as the

drainage aids to prepare the fracturing fluid for experiment, the viscosity of the gel breaker reached 1.3 mPa·s, the interfacial tension between the gel breaker and kerosene reached 1.05 mN/m, and the surface tension was 22.8 mN/m. The fracturing fluid has good flowback performance. By collecting 4 core samples from ZJ block, the gas permeability of core samples is selected as three permeability sections $0.05 \cdot 10^{-3}$ μm², $0.15 \cdot 10^{-3}$ μm² and $0.25 \cdot 10^{-3}$ μm². And the correlation experiments of water sensitive damage, water lock damage and solid damage are carried out. The results show that when the permeability of the fracturing fluid decreases from $0.25 \cdot 10^{-3}$ μm² to $0.05 \cdot 10^{-3}$ μm², the damage value of the permeability section of the JS experimental group also increases from 8.25% to 18.35%, the movable water retention also increases from 0.032 PV to 0.046 PV, and the bound water increase increases from 0.032 PV to 0.086 PV. Therefore, the smaller the osmotic pressure is, the greater the retained amount of movable water and the increased amount of bound water are, and the greater the damage value of fracturing fluid is. In addition, when the mass fraction of XJHX in this experiment reaches 0.8%, its anti-swelling rate can reach 85%, which has excellent anti-swelling performance and can effectively reduce the permeability damage caused by fracturing fluid to shale formation.
Keywords: *fracturing fluid, water sensitive injury, water lock injury, injury mechanism, control method.*

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Study on a New System of Water Unlocking in Tight Sandstone Gas Reservoirs

In order to solve the problem of water lock blockage in the wellbore of Daniudi gas field, the main surfactant APG and CG-1, CG-2, WR and other surfactants were used to produce co-energy and synergistic effect through the combination of multiple surfactants. The static properties of the agent were evaluated by measuring the interfacial tension, surface tension and contact Angle of the surfactant system. According to the physicochemical mechanism of the synergistic action of compound surfactants, the water lock of the combination of anionic surfactants and non-ionic surfactants is preferred. A new water unlocking agent system for tight gas reservoirs was developed: APG (0.3%) +CG-1(0.2%) +SYH (0.1%) +KCl (2%). The interfacial tension between the system and simulated oil was $9.61 \cdot 10^{-4}$ mN/m, the surface tension was 18.2 mN/m, and the gas/liquid/solid three-phase contact antenna was 99.4°. Daniudi tight core (core No. 602-14) was used to simulate the process of high temperature and high-pressure water lock damage. The permeability recovery rate after injection of waterproof lock agent is 25.36% compared with water lock damage.

Keywords: *tight gas reservoir, water lock damage, surfactant, water lock agent.*

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Research on the Sedimentary Characteristics and Oil Accumulation Laws

The key to the development of oil and gas resources in the Tamulangou Formation in the Huhehu Sag of the Hailar Basin lies in the understanding of sedimentary characteristics and the division of volcanic-sedimentary cycles. These cycles are divided into five sedimentary systems, namely alluvial fans, braided rivers, fan deltas, braided river deltas, and lacustrine systems. Based on the lithological characteristics, sedimentary structures, geometric forms, and definitions of the Huhehu Sag. The volcanic-sedimentary sequences of the Tamulangou Formation are dominated by intermediate-basic volcanic rocks and acidic volcanic rocks and they are located at the uppermost part of the Huhehu Sag. The Huhehu Sag gou Formation contains thin-bedded sedimentary rocks and locally thick-bedded sedimentary rocks, with localized development of the 148 Ma Manitu Formation volcanic-sedimentary sequence. The source rocks in the Huhehu Sag are of moderate to good quality. And the main controls on hydrocarbon accumulation are the distribution of hydrocarbon source rocks, development of fault zones, characteristics of fan deltas, and volcanic-sedimentary processes.

Keywords: *sedimentary characteristics, hydrocarbon characteristics, Huhehu Sag, Tamulangou Formation.*

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Reliability Evaluation of Clean Energy Internet Information Security

Based on Statistical Learning Methods

The large-scale exploitation and wanton use of fossil energy have led to the increasing global warming and environmental pollution. The development and utilization of clean energy urgently need to be put on the agenda. At the same time, the development of Internet technology and big data technology is constantly promoting the development and popularization of clean energy. However, Internet information security is the number one factor threatening the development and supply of clean energy in today's society. Therefore, based on the relevant theories of statistical learning, an evaluation model of information security reliability of clean energy internet based on statistical learning is constructed. At the same time, the reliability of the evaluation model is tested and analyzed. Finally, the role of the evaluation model in the carbon sequestration of natural gas hydrate, the reduction of greenhouse effect and the development of clean energy is analyzed. It is expected to lay a foundation for the efficient

development and environmental protection of clean energy (natural gas) through this research. It is found that the predicted results of data transmission by coaxial cable are completely consistent with the actual results, and neither will generate hydrate within 2.5 m from the entrance. Moreover, the reliability of data transmission using coaxial cable is higher than that of wireless transmission. The study also found that the increase of carbon dioxide injection rate will accelerate the decomposition and gas production of hydrate, and it is more obvious in the small range of carbon dioxide injection rate. Considering the development efficiency and burial efficiency, the carbon dioxide injection rate is designed as $20 \cdot 10^4$ m^3/day is the best. At the same time, the greenhouse effect of carbon dioxide will become more and more significant with the increase of its concentration, and based on the prediction of the built model, it is found that the replacement rate of natural gas in hydrate by carbon dioxide can reach 92.35%.
Keywords: *clean energy, statistical learning method, information security, natural gas, greenhouse effect.*

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Geochemical Characteristics and Main Controlling Factors of Middle-Upper Cambrian Carbonate Reservoir

The Cambrian system in the Ordos Basin has good exploration potential, and the Zhangxia Formation and the Sanshanzi Formation of the Middle and Upper Cambrian are important targets for the exploration of the Cambrian system. In this paper, the characteristics, genesis and main controlling factors of the Zhangxia Formation and the Sanshanzi Formation reservoir are studied through field section observation, thin section observation, drilling and geophysical logging data combined with experimental analysis data. The reservoir space types of the Cambrian carbonate rocks in the Ordos Basin mainly include intercrystalline pores, intercrystalline dissolution pores, dissolution pores, dissolution sutures and dissolution fractures, among which intercrystalline dissolution pores, dissolution pores and dissolution fractures constitute the most important reservoir space type. There are three reservoir types: pore type, fracture - dissolution cavity type and fracture type. The development of Cambrian strata in Ordos Basin is mainly controlled by three factors: high-energy sedimentary facies zone, epigenetic diagenesis and tectonic movement. Granular beach facies and dolomite tidal flat facies are favorable zones for reservoir development in Zhangxia Formation and Sanshanzi Formation. The fault zone in the basin provides a migration channel for late hydrothermal fluid, which can significantly improve reservoir performance. Tectonic fracture itself is an effective pore system, which becomes the migration channel of geological fluid, and also plays a role in communicating pores, which plays a positive role in reservoir.

Keywords: *carbonate reservoir; pore characteristics; geochemical characteristics; main control factor.*

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Study on the Lithological Characteristics and Its Controlling on the Development of Specific Tight Sandstone Reservoirs

Diagenesis is a series of physical and chemical reactions that take place after deposition. Using cores, thin sections, cathode luminescence, X-ray diffraction, scanning electron microscope, inclusions analysis, geochemical analysis and pore permeability data, the diagenesis, and its influence on the tight sandstone reservoir of Xu 2 member in the southwest Sichuan Basin has been analyzed. The reservoirs of the southwest Sichuan Basin mainly consist of feldspathic feldspathic sandstone, feldspathic feldspathic sandstone, and felsic sandstone, with an average porosity of 3.57% and an average permeability of $0.138 \cdot 10^{-3}$ μm^2, which are typical tight sandstone reservoirs. The sandstones in the Xu2 member mainly underwent compaction, dissolution, cementation and accounting, and the specific evolution process is compaction , first-phase fracture, first-phase quartz increase, first-phase calcite cementation, second-phase fracture, feldspar and rock chip dissolution, second-phase quartz increase and silica filling, chlorite cementation or illite cementation, second-phase calcite cementation, dissolution, third-phase quartz increase and silica filling, the third stage of carbonate cementation, carbonate accounting for feldspar and quartz- third stage of tectonic fragmentation, late calcite or quartz cementation into rocks. And the rock formation stage is mainly mesodiagenesis B stage. The secondary pores and microfractures are the main reservoir space in the Xu 2 member sandstone reservoirs. Strong compaction and carbonate cementation are the main reasons for the tight sandstone reservoir, and dissolution and fracture are the main constructional effects for the development of the dominant reservoir.

Keywords: *tight sandstone reservoir, test analysis, reservoir characteristics, diagenesis, controlling factors.*

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Environmental Regulation and Total Factor Carbon Productivity

This study investigates the relationship between environmental regulation and total factor carbon productivity in China's industrial sectors. Using panel data analysis from 2000 to 2016, we find that environmental regulations significantly enhance carbon productivity. We also examine the mediating effect of environmental regulation and analyze the dynamic effects using a threshold effect model. The results reveal a non-linear relationship, where stricter regulations may increase carbon emissions beyond a certain threshold. The study emphasizes the importance of energy allocation and technology development in shaping carbon productivity outcomes. Promoting innovation, developing a clean energy system, and implementing effective environmental regulations are crucial for improving total factor carbon productivity and achieving sustainable economic growth.
Keywords: *environmental regulation, carbon productivity, energy allocation, technology development, threshold effect.*

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Main Elements Geochemistry Implication of Meso-Cenozoic Tectonic Evolution

The apatite and zircon fission track (FT) analysis offers the opportunity to reveal the chronology records for Meso-Cenozoic tectonic events in the Northeast of Ordos Basin, China: the Indosinian Epoch tectonic events mainly occurred at (245-235 Ma±) with a peck-age of 240 Ma and (205-195 Ma±) with a peck-age of 200 Ma, corresponding to the parallel unconformity during the Middle and Lower Triassic to Upper Triassic, the angular unconformity during the Late Jurassic to its underling layers. Middle Yanshanian tectonic events occurred at (155-115 Ma±) with a peck-age of 135 Ma, and corresponded to the angular unconformity during Lower Cretaceous to its underling layers. Late Yanshanian to Himalayan tectonic events included at least two episodes, peak-age respectively is (65Ma±) and (20 Ma±). On this basis, we further complete their main elements geochemical analysis. The contents of TiO_2, Fe_2O_3+MgO, Lg ($SiO_2/A1_2O_3$) in samples was 0.18-1.02%, 1.23-8.55%, and 0.59-1.04%, respectively. The average was 0.53%, 4.5%, 0.71%, respectively. Based on the discriminant plate of the main element, the transition events of the important sedimentary structure environment in phase two were obtained. The relationship analysis of the tectonic event and the mineralizing chronology revealed that the key tectonic events control reservoir forming time or mineralization time of the coupling coexistence of multiple energy resources in the Northeast of Ordos Basin, and show the collaborative and coupled relationship between the tectonic events and accumulation (mine).

Keywords: *geochemistry implication, Meso-Cenozoic, main elements, tectonic events, Ordos Basin.*

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Simulation of the Influence of Fracture Gas State on Gas-Liquid Replacement Based on Fluent Two-Phase Flow

Aiming at the hazards caused by drilling into fractured formations during oil drilling, linear prediction of physical properties of CO_2/H_2S under different well depths are carried out, based on Fluent to simulate gas-liquid placement in near-critical, critical and supercritical states of gas. The results show that when the well depth is small, the CO_2/H_2S near-critical state and the initial bottom hole pressure of the critical state invading the annulus are lower than the formation pressure, and the gas invading the annulus is suspended in the annulus until the hydrostatic pressure of the missing drilling fluid is supplemented for about 1s and 1.2 s respectively, the formation pressure can be balanced before the upward return can be continued; the bottom hole pressure of the supercritical state invades the annulus rapidly drops within 2 s; the gas-liquid replacement rate in the supercritical state is slower than that in the non-supercritical state, with a difference of 60-80 s. During the drilling process, it can be judged according to the bottom hole pressure change whether it has encountered a fractured formation and the state of the gas contained, and well control measures should be taken in time.

Keywords: *supercritical state, gas-liquid multiphase flow, multiphase flow, phase change, well control.*

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Analysis of Influencing Factors of Pile Penetration of Jacket Platform Skirt Pile

Pile penetration is a very important engineering parameter in pile sinking operation of jacket platform. Insufficient penetration may lead to insufficient bearing capacity of pile foundation, resulting in platform instability and extremely serious safety accidents. In the process of actual pile sinking operation, the

penetration is affected by many factors. In this paper, through relevant calculation and analysis, the influencing factors such as internal friction angle, pile diameter, hammer distance and hammer quality are studied, and the influence law of pile penetration is obtained. Finally, relevant suggestions are given in order to provide reference for engineering practice.
Keywords: *jacket platform, length of penetration, pile driving works, influencing factor, engineering practice.*

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Renewable Energy Technology Innovation Effect on the Economics Growth

With rapid economic expansion, China is faced with environmental challenges like air pollution and greenhouse gas emissions. Shifting from conventional fossil fuels to renewable energy (REN) sources is critical to facilitate sustainable development in China. Compared to coal and oil, REN such as solar and wind energy emit less carbon emissions. Fostering innovation of REN technologies is thus essential for China's green transition. This study aims to analyze the impact of REN technology innovation on China's economic growth using panel data models. The results demonstrate that advancing REN technologies significantly promotes GDP increase in China. Targeted policy incentives must be implemented to accelerate REN technology progression and adoption across the country. Transitioning towards REN systems will be instrumental for China to achieve environmental sustainability while maintaining economic growth.

Keywords: *energy consumption, environment pollution, market integration, technology innovation.*

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Pore Structure and Methane Adsorption Characteristics
of Primary Structural and Tectonic Coals

In this paper, the pore structure and methane adsorption properties of the primary structural and tectonic coals of the Handan Jiulong Mine were analyzed using low-temperature nitrogen adsorption experiments and isothermal adsorption tests. The relationship between pore structure and adsorption properties was discussed. The study results show that the total pore volume and specific surface area of the tectonic coal in the Jiulong Mine are larger than those of the primary structural coal. Small pores comprise most of the pore volume in the primary structural coal, followed by micropores and medium pores. The pore volume of the tectonic coal primarily consists of small pores, followed by micropores and medium pores. Micropores and medium pores consist of approximately the same volume. The specific surface area of both the tectonic coal and the primary structural coal is primarily micropores, followed by small, and medium pores. The microporous and small pore structures of the tectonic coal have open pore morphology. The pore shapes are primarily in the shape of ink bottles. The coal sample of primary structural coal contains both open pore morphology and numerous closed pore morphology. The pore shape is mainly columnar. The pressure-boosting adsorption process of coal samples conforms to the Langmuir isothermal adsorption equation. The maximum adsorption capacity of tectonic coals is greater than that of primary structural coals. The adsorption capacity and Langmuir volume (VL) of coal samples decrease with increasing temperature, while the Langmuir pressure (PL) increases with temperature. The larger the pore volume of coal samples, especially the micropore volume, the greater the adsorption capacity, and the richer the specific surface area of micro-pores, creating a more substantial adsorption capacity.

Keywords: *Jiulong Mine, primary structure coal, tectonic coal, pore structure, adsorption.*

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Study on Seepage Characteristics and Capacity Evaluation of Shale Gas Reservoirs

The formation, storage and seepage characteristics of shale gas reservoirs are significantly different from those of conventional oil and gas reservoirs, and their in-depth study is extremely important for improving energy security and promoting sustainable development. In this paper, based on the nonlinear seepage theory of shale gas reservoirs and the capacity analysis of test wells, a steady state capacity model integrating the apparent permeability model and the multi-scale transport mechanism is constructed to investigate the influence of various factors on the apparent permeability and the capacity of shale gas fractured horizontal wells, as well as to predict the production of shale gas wells. It is found that: apparent permeability is significantly affected by pore radius, and the non-Darcy effect is

particularly significant under low-pressure and small-scale pore conditions; when the reservoir pressure is lower than 15 MPa, the sensitivity of apparent permeability to temperature and Langmuir volume increases, but decreases with the increase of Langmuir pressure; and the production capacity analysis of shale gas reservoirs shows that the production rates of fractured wells that consider the multiscale transport mechanism are generally higher than those considering Darcy flow only, especially in the case of low wellbore pressure and large pore radius; the effects of Langmuir volume and pressure on the production capacity are relatively small, and mainly noticeable in the range of wellbore flow pressure from 1 MPa to 15 MPa. The number of fracture bars has a significant effect on production, but too many fractures can lead to gap interference, which slows down production growth. The results of this research provide theoretical support for the scientific development of shale gas reservoirs and have important research and application value for the efficient and rational development of actual well sites.
Keywords: *shale gas reservoirs: seepage characteristics; apparent permeability; multiscale; capacity evaluation.*

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Study on Stress – Fluid Coupling of Coal Seam Floor Water Outburst Based on Flac 3D Simulation

Coal mine water outburst under fluid-solid coupling is a hot topic in coal geology. In this paper, the FLAC 3D simulation method is used to systematically study the water outburst problem of fluid coupling with coal mine floor. The results show that the vertical stress of the floor in the goaf has an obvious downward trend after coal seam excavation. Under the joint influence of mine pressure and bearing water pressure, the working face before the old roof pressure can be affected by two stages: the first stage is the advance pressure compression section on both sides of the working face, and the other stage is the pressure relief expansion section under the goaf. Before the old roof is pressed, the shear stress near the roof and floor is also affected to some extent. The front and rear displacement value of the goaf is negative, which is the result of the advance supporting pressure. The effective thickness of the floor waterproof layer decreases gradually with the advance of the working face. When the working face continues to advance, there will be a risk of water outburst. With the increasing width of the working face, the height of the guide belt increases. Therefore, in the process of mining activities, a variety of factors should be considered comprehensively, and a reasonable width of the working face should be selected to ensure the safety of mining.

Keywords: *coal mine safety, coal mine water outburst, FLAC 3D, width of working face, supporting pressure.*

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The Method of Seismic Diffraction Wave Extraction Based on PCA Method and Its Application

This paper addresses the challenge of accurately describing the boundary of deep cavern-type reservoirs. A method is developed to extract diffraction information from the cavern and its boundaries from full wavefield seismic data using PCA wavefield separation technology. The paper describes a method for extracting diffraction information based on post-stack seismic data, and demonstrates the validity of this method in identifying cavern's boundaries via forward modeling. Subsequently, the method is applied to actual seismic data to extract diffraction information from deep caverns. By separating wavefield information at different scales, the extracted diffraction information can effectively identify the characteristics of cavernous reservoirs and their boundaries. It is verified by examples that the diffraction wave information separation method can provide a more accurate description of the distribution of deep cavern-type reservoirs, which can provide a basis for predicting this type of reservoir.

Keywords: *diffracted wave information separation, principal component analysis, karst cave, diffraction wave field forward modeling, boundary recognition.*