Mountjoy IV
10–13 August 2025
Montreal, Canada

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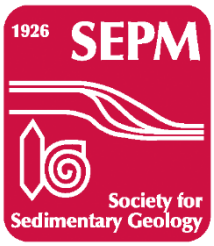

Mountjoy IV Conference
10–13 August 2025, Montreal, Canada

Sunday, 10 August

17.00–19.00 *Pre-Conference Icebreaker*
Redpath Museum

Monday, 11 August

7.30–8.30 *Registration and Coffee*

8.30–8.40 *Conference Welcome and Introduction*

Carbonate Depositional Systems Technical Talks—Session Chair: Jean Hsieh

8.40–9.00 A deep-water refuge for reefs during extreme ocean warming: Triassic metazoan-algal reefs originated on mesophotic to dysphotic carbonate platform slopes following the end-Permian extinction—*Brian Kelley*, Xiaowei Li, Evan Ritchey, Joshua Garber, Demir Altiner, Meiyi Yu, Jonathan Payne, Daniel Lehrmann, Marcello Minzoni, Clark Sherman*

9.00–9.20 New insights on the evolution of carbonate platforms in the Red Sea—*Tihana Pensa*, Guillaume Baby, Thomas Teillet, Antoine Delaunay, Antonio Delgado-Huertas, Abdulkader Alafifi*

9.20–9.40 Why is the bucket empty? An underfilled carbonate lagoon in the Red Sea—*Volker Vahrenkamp*, Indah Putri, Akbar Wicaksoni, Thomas Lüdmann, Christian Betzler, Gianluca Frija, Anna Cipriani, Alexander Petrovic*

9.40–10.00 *Break*

Carbonate Cyclicity Technical Talks—Session Chair: John Rivers

10.00–10.20 Response of Ediacaran shallow marine carbonates to orbital climate forcing: insights for thrombolitic patch reefs and laminites of the Huns microbial platform—*Ajani Bissick*, Bianca Spiering, Andrea Boscaini, Joshua Davies, Galen Halverson, Brandt Gibson, Marc Laflamme, Frederik Hilgen*

10.20–10.40 Impact of astronomically-driven climatic and oceanographic cyclicity on microbial carbonate sediment production and facies distribution in a semi-restricted basin: Upper Jurassic Smackover Formation, Alabama—*Marcello Minzoni*, Berry Tew, Bradford Prather*

10.40–11.00 Ordovician carbon cycle and sequence stratigraphy: insight from the St Lawrence platform, Quebec—*Claire Musajo*, Heloïse Pinon, Ajani Bissick, Morgann Perrot, Joshua Davies, Galen Halverson*

11.00–11.20 *Poster popups*

11.20–12.00 ***Poster Viewing***

12.00–13.30 *Lunch*

Microbialite Technical Talks—Session Chairs: Art Saller and Mariane Cristina Trombetta

13.30–13.50 Pre-salt lacustrine reservoirs; new ideas and concepts for the structural evolution of the conjugate margin, lake hydrology and depositional models—*Darryl Green**

13.50–14.10 Sea-level and paleoenvironmental controls on thrombolite reef growth following rapid marine flooding of an epicontinental basin, basal Windsor Group (Mississippian), Cape Breton, Canada—*Edward Matheson*, Zailynne Durant, George Bradley*

14.10–14.30 Carbonate-rich lacustrine systems—the Green River Formation, western USA and the pre-salt of Brazil—chemistry and climate, shorefaces, microbes, and minerals—*JF (Rick) Sarg**

14.30–14.50 *Break*

Microbialite Technical Talks—Session Chairs: Art Saller and Mariane Cristina Trombetta

14.50–15.10 Early marine microbial diagenesis in the Abu Dhabi Lagoon (UAE): field experiments and temporal quantification using CT-scan and SEM—*Thomas Teillet*, Ronell Sicat, Domingo Lattanzi, Charlène Odobel, Elisa Garuglieri, Kai Hachmann, Daniele Daffonchio, Mónica Sánchez-Román, Volker Vahrenkamp*

15.10–15.30 Stratigraphy and preservational variation of reef-building microbialites in the Tonian Reefal assemblage (Fifteenmile Group) of Yukon—*Charlotte Spruzen*, Galen Halverson*

15.30–17.00 ***Poster Viewing***

Monday Poster Presentations

- Lithocodium presence in the Jurassic Arabian Plate carbonates: paleontological and diagenetic insights into enhancing reservoir quality—*Maha Almulla**
- Geochemical variations in the large benthic foraminifera *Sorites orbiculus* from a land-attached Red Sea lagoon, Saudi Arabia: potential proxies for monitoring environmental conditions in modern and ancient lagoons—*Francesca Giovenzana*, Klimentsi Cherviakouski, Ksenia Kaprielova, Volker Vahrenkamp*
- From the intertidal to the aphotic—microbes are a ubiquitous and essential component of lithifying carbonate platforms in the Red Sea—*Kai Hachmann*, Elisa Garuglieri, Rawan Alhazmi, Ramona Marasco, Viswasanthi Chandra, Daniele Daffonchio, Volker Vahrenkamp*

- Impact of sea-water chemistry on carbonate sediment production and stratigraphic architecture of progradational microbial-oolitic carbonate margins—*Marcello Minzoni*, Souvik Bhattacharjee, Berry Tew, Bradford Prather*

- Exploring the mesophotic geomorphologies of the Saudi Arabian Red Sea continental shelf—*Thomas Teillet*, Guillaume Baby, Antoine Delaunay, Arman Kudbanov, Ronell Sicat, Abdullah Mandili, Dimitris Sakellariou, Fabio Marchese, Francesca Benzoni, Carlos Duarte, Abdelkader Al Afifi*

- Characterization of thrombolites in the Huns platform of the Nama Group, Namibia—*Ava Whitehead*, Ajani Bissick, Galen Halverson*

- Diatoms diminish dolomite—*Huifang Xu*, Yihang Fang, Franklin Hobbs*

Tuesday, 12 August

7.30–8.30 *Coffee*

8.30–8.40 *Day 2 welcome*

Carbonate Diagenesis Technical Talks—Session Chairs: Cole McCormick and Thomas Teillet

8.40–9.00 Late Permian Zechstein carbonates of the Utsira High, Norwegian North Sea—*Niels Rameil*, Ingrid Gianotten, Israel Polonio, Kasper Blinkenberg, Lars Stemmerik*

9.00–9.20 Aragonite neomorphism, aragonite-calcite seas and pCO_2—*Arthur Saller**

9.20–9.40 A new method for reconstructing hydrocarbon accumulation history of deep to ultra-deep carbonate reservoirs—*Anping Hu, Anjiang Shen, Zhanfeng Qiao**

9.40–10.00 *Break*

Carbonate Diagenesis Technical Talks—Session Chairs: Cole McCormick and Thomas Teillet

10.00–10.20 Pore to core plug scale characterization of porosity and permeability heterogeneities in a Cretaceous carbonate reservoir using laboratory measurements and digital rock physics, Abu Dhabi, United Arab Emirates—*Abdulquadri Alabere*, Mohamed Soufiane, Mohammad Alsuwaidi, Daniel Morad, Fadi Nader, Fateh Bouchalaa, Emad Al-Shalabi, Osama Al Jallad*

10.20–10.40 Human-induced diagenetic alterations in fine-grained carbonates driven by seawater flushing: Tor Formation, Chalk Group, Danish North Sea—*Umid Kakemem*, Kasper Blinkenberg, Julian Espana Zapata, Kresten Anderskouv*

10.40–11.00 Evolution of diagenesis and reservoir quality in Brazilian pre-salt resedimented carbonate rocks from the Santos Basin—*Mariane Cristina Trombetta*, Sabrina Danni Altenhofen, Jaques Soares Schmidt, William Da Silveira Freitas, Rosalia Barili, Amanda Goulart Rodrigues, Luiz Fernando De Ros*

11.00–11.20 *Poster popups*

11.20–12.00 ***Poster Viewing***

12.00–13.30 *Lunch*

Karst/Structural Geology and Fractures Technical Talks—Session Chair: Sherry Becker

13.30–13.50 Geothermal carbonate reservoirs—exploiting a karstified carbonate reservoir in the north alpine foreland basin, Germany—*Joachim Amthor*, Daniel Bendias, Kilian Beichel*

13.50–14.45 *Break*

14.45–15.50 ***Red Path Museum Tour***

15.50–17.00 ***Poster Viewing***

18.30–20.30 ***Conference Dinner***

Tuesday Poster Presentations

- Petrographic characteristics of Friktia Onyx marble, northeastern Algeria—*Ait Abdelouahab Djaouza*, Nasri Fatah, Ouidad Laziz*
- Development and application of new technologies of trace element testing for carbonate minerals—*Feng Liang*, Anping Hu*
- Zebra textures in fault-controlled, hydrothermal dolomite bodies: coupled mechanisms of replacement, deformation, and cementation—*Cole McCormick*, Ernest Rutter, Hilary Corlett, Matthew Steele-MacInnis, Eivind Block Vagle, Fiona Whitaker, Cathy Hollis*
- Fluid activities and reservoir forming mechanisms associated with strike-slip faults: a case study of Ordovician in Fuman area, Tarim Basin, northwest China—*Zhanfeng Qiao*, Tianfu Zhang, Jiajun Chen*
- The equipment innovation of dissolution modelling and its application on porosity formation and preservation in deep-buried carbonate—*Min She*, Anping Hu*

Wednesday, 13 August

7.30–8.30 *Coffee*

8.30–8.40 *Day 3 welcome*

Carbon capture, utilization, and storage (CCUS)/Critical Mineral Resources (CMR) Technical Talks—Session Chair: Imelda Johnson

8.40–9.00 A core-based assessment of the Leduc Formation carbonates in central Alberta, a prime candidate for CO_2 sequestration—*Tyler Hauck*, David Herbers, Mark Mallamo*

9.00–9.20 CCS in fine-grained carbonate reservoirs—experiments, petrography, and modeling of the Chalk Group, Danish North Sea—*Umid Kakemem*, Kasper Blinkenberg,*

Nikolai Andrianov, Nicolas Bovet, Knud Dideriksen, Peter Frykman, Wael Fadi Al-Masri, Samira Mohammadkhani, Hanne Dahl Holmslykke, Theis van Beek Pedersen, Behzad Rostami, Kresten Anderskouv

9.20–9.40 An overview of the Devonian analogue investigation—revisiting the Devonian of western Canada with 3D digital outcrop models—*AJ MacNeil**

9.40–10.00 *Break*

Carbonate Dolomitization Technical Talks—Session Chair: Matt Buoniconti

10.00–10.20 The role of recrystallization in shaping the geochemical signature of dolomite: an experimental study—*Cole McCormick*, Dalton Hardisty, Chelsea Pederson, Watts Deitrich, Isaac Bondzie-Selby, Mohammed Hashim, Kimberly Lau*

10.20–10.40 Dolomite recrystallization as characterized by crystal texture and Mg-C-O isotopes: a case study of Lower Ordovician dolomite from Tarim Basin—*Hairuo Qing*, Zhanfeng Qiao, Siyang Zhang*

10.40–11.00 Warm acidified seawater and dolomite formation—*John Rivers**

11.00–11.20 *Poster popups*

11.20–12.00 ***Poster Viewing***

12.00–13.50 *Lunch*

Carbonate Dolomitization Technical Talks—Session Chair: Alex MacNeil

13.50–14.10 Bioturbation controls patterns of dolomitization in Lower Jurassic carbonates on central Saudi Arabia—*Moaz Salih*, Hassan Eltom, Robert Goldstein, Francisco Rodríguez-Tovar*

14.10–14.30 500-year wet/dry cycles and extreme hydroclimate events between early-1100s and mid-1200s recorded in Deep Springs Lake, California—*Huifang Xu*, Jianru Cheng*

14.30–14.45 *Final Remarks and closing of talks*

14.45–15.00 Break

15.00–16.00 ***Poster Viewing***

16.00 Informal Sundowner

Wednesday Poster Presentations

- Energy transition opportunities in an old oil field—Judy Creek Beaverhill Lake Unit, Alberta, Canada—*Andre Chow*, Michelle Lund, Joel Collins*
- Age and temperature of authigenic carbonates associated with lithium-bearing illite claystones at Thacker Pass, Nevada, USA—*Kevin Hatton*, Troy Rasbury, Gregory Henkes, Jason Kirk, Chris Russo, Francis Sousa, Kathleen Wooton, Steven Jaret, Thomas Benson*

- Maximizing oil recovery and carbon storage at Redwater Leduc: a blueprint for sustainable energy development—*Michelle Lund, William Sawchuck, Andre Chow**
- Genesis of dolomite of the Middle Permian Maokou formation in central Sichuan Basin: based on petrological, geochemical, and chronological evidence—*Jianfeng Zheng**

*Presenter

Monday
11 August 2025

Oral and Poster Presentations

A deep-water refuge for reefs during extreme ocean warming: Triassic metazoan-algal reefs originated on mesophotic to dysphotic carbonate platform slopes following the end-Permian extinction

Oral Presentation
Keywords: reefs, carbonate platform slopes, mesophotic zone, Triassic

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Mesophotic (30–150 m) and deeper dysphotic depth zones have been hypothesized as potential refuges for shallow-marine ecosystems during future climate warming because they can reduce heat stress. To test this hypothesis, we integrated field mapping, satellite imagery analysis, quantitative petrography, and cerium anomaly (Ce/Ce*) measurements to investigate the paleoenvironmental context of metazoan-algal reef recovery during the Early–Middle Triassic hothouse. Following the end-Permian extinction, metazoan-algal reefs were absent for 8–10 m.y. Our investigation of the oldest-known Triassic reefs indicates that reefal boundstone first occurred in upper Lower Triassic strata in ~150–475 m of paleo water depth and was dominated by marine cement and *Tubiphytes*. The earliest metazoan framework builders (sphinctozoan sponges) emerged in a similar depth range in the lower Middle Triassic, ~ 1–2 m.y. later. Framework-contributing calcareous algae and scleractinian corals occurred later in a euphotic to shallow mesophotic depth range. Although photosynthesizers were restricted to shallower environments, metazoan framework volume remained higher in deeper mesophotic settings of the early Middle Triassic. Rare earth element analyses indicate that, following prolonged slope anoxia, reef initiation coincided with episodic slope oxygenation, but increased metazoan abundance and biodiversity postdated persistent oxygenation. In combination with previous studies, our findings indicate that reef initiation occurred during the waning Early

Triassic hothouse and that later Middle Triassic reef biodiversification was associated with persistent slope oxygenation, reduced atmospheric CO_2, lower ocean temperature, a less vigorous biological pump, and stabilization of the carbon cycle. Although depth-generalist reef taxa found refuge in mesophotic to dysphotic slope habitats during extreme warming, temperature-sensitive, photosynthesizing taxa lacked viable refuges. Future extreme warming events could thus force what remains of shallow-marine ecosystems into deeper water while promoting the proliferation of depth-generalist and heat-tolerant taxa, fundamentally altering the distribution and composition of marine ecosystems.

New insights on the evolution of carbonate platforms in the Red Sea

Oral Presentation
Keywords: Red Sea basin, rift evolution, strontium isotopes, salt tectonics

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The Red Sea basin provides a detailed geological record of carbonate production in a rifted passive margin. This study integrates field observations, seismic and well data, and strontium isotope stratigraphy to reconstruct the carbonate depositional system over the past 23 million years.

The Red Sea rift propagated from south to north, and it was initially flooded by seawater from the Neo-Tethys at the start of the Miocene. This connection became restricted between 16 and 6.2 Ma, resulting in extensive evaporite deposition in a post-rift sag basin. Late Miocene reflooding established a new connection with the Indian Ocean. Carbonate platform development occurred during two phases: the syn-rift phase (23–16 Ma) and the post-evaporite phase (6.2 Ma–present).

Rift structures controlled Early to Middle Miocene carbonate deposition. Carbonates colonized shallow waters over the eroded footwalls of normal faults in tilt blocks/half grabens along the rift margins. Early Miocene platforms were mollusk-dominated, transitioning to coral and red algae-dominated fringing and delta-top platforms in the Middle Miocene. Initially confined to the northern Red Sea, carbonate platforms expanded southward during the late syn-rift stage, outcropping along an 800 km stretch of the Saudi margin.

Strontium isotope dating indicates that carbonate production resumed at 6.2 Ma following the evaporitic phase. Fringing reefs colonized the coast but were later detached by raft tectonics over the ductile salt layer, gliding up to 30 km offshore. Some of the detached reefs aggraded into keep-up reefs up to 800 meters thick as they glided into deeper waters, while others drowned and were buried by sediments. These reefs represent the world's best examples of reef growth and detachment influenced by salt tectonics.

Our results provide new insights into the dynamic interplay between extensional thick- and thin-skinned tectonics and carbonate platform development in rifted and passive margin settings.

Why is the bucket empty? An underfilled carbonate lagoon in the Red Sea

Oral Presentation
Keywords: underfilled lagoon, climate, sea level, Red Sea

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What leads to the formation of a deep lagoon that persist over multiple ice-house sealevel cycles? This question arises from a detailed investigation of the large land-attached Al Wajh lagoon, northern Red Sea, Saudi Arabia. We highlight the potential of carbonates to constrain their own growth by creating “un-healthy” environments in an otherwise ideal tropical carbonate factory setting. We hypothesize that the self-made environmental restrictions are born out of climate, high frequency sealevel fluctuations and the vigorousness of carbonate growth.

Insights are based an extensive data set of 2D seismic and hydroacoustic surveys, multi-depth instored 150 environmental loggers recording data over a full year cycle, drill cores, Sr-isotope dates and scuba-dive observations.

The Al Wajh lagoon of arid northwest Saudi Arabia is a large (60km x 30km) land-attached carbonate terrain with a near-continuous reef rim towards the deep Red Sea. The age of the carbonate section is constrained by Sr-isotopes as late Pliocene/Pleistocene. Seismic profiles indicate minor tectonic deformation over the growth period. The lagoon has several sub-basins reaching 42 m maximum depth. Logger data indicate the generation of stratification during the winter/spring with cold saline bottom waters. The waters are murky and laden with organic substances. Stratification collapses in the late spring leading to turnovers and algae blooms during the summer. Despite the existence of some 60 islands and shallow shoals all with coral-reef rims/veneers the environment at depth is not conducive to active coral growth preventing infill of the lagoon. Hydroacoustic data reveal that coral reefs are seeded during reflooding of the

lagoon when sealevel rises, but are rapidly quenched, drowned and buried by accumulating lagoonal wacke-packstone sediments.

The results indicate that the bucket shape created by a vigorous coral reef rim together with the seasonal climate fluctuations under arid conditions prevent the lagoon to be filled.

Response of Ediacaran shallow marine carbonates to orbital climate forcing: insights from thrombolitic patch reefs and laminites of the Huns microbial platform

Oral Presentation
Keywords: sequences, carbonates, Ediacaran, Milankovitch

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The Huns Member of the late Ediacaran Schwarzrand Subgroup (southern Namibia) preserves a well-exposed shallow-marine carbonate platform within the Witputs sub-basin, offering a valuable record of high-frequency sea-level fluctuations and their relationship to orbital climate forcing. This study presents new findings from a refined sequence stratigraphic framework, integrating drone photogrammetry and cyclostratigraphic analysis, to assess how orbital-scale climate dynamics influenced platform evolution. The sedimentary succession records a large-scale transgressive sequence, overprinted by approximately ten higher-order sequences (H1–H10), with thicknesses varying from 25 to 60 meters. The spatial consistency of these cyclic sequences across the sub-basin and their estimated duration based on available U-Pb zircon ages from volcanic ash beds suggests that Milankovitch cycles[1,2], most likely short eccentricity (~100 kyr)[2] —played a primary role in the development of these higher order sequences. The lower sequences (H1–H4) are the thickest (~60 m), with H1 and H2 dominated by well developed transgressive siliciclastic-rich deposits, reflecting early accommodation infill. A major environmental shift

is recorded in H3–H4, with a marked increase in carbonate sedimentation, the development of a distinct dolomitic marker bed and appearance of transient thrombolitic patch reefs. H5–H7 records continued deepening and culminates with the introduction of a subtidal laminated facies. In contrast, the uppermost sequences (H8–H10) signal the onset of the catch-up phase, characterized by increasing evidence of subaerial exposure. By situating these findings within the tectonic context of the late Neoproterozoic Witputs sub-basin, this study enhances our understanding of the depositional history of the Huns platform and provides a framework to better assess how orbital-scale climate dynamics and environmental changes may have interacted in these carbonate environments.

References

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Spiering, B. R., Bissick, A., Darroch, S. A. F., Davies, J. H. F. L., Gibson, B. M., Halverson, G. P., Laflamme, M. and Hilgen, F. J. 2023. Initial cyclostratigraphy of the middle Nama Group (Schwarzrand Subgroup) in southern Namibia. Precambrian Research, 397: 107200-.

Impact of astronomically-driven climatic and oceanographic cyclicity on microbial carbonate sediment production and facies distribution in a semi-restricted basin: Upper Jurassic Smackover Formation, Alabama

Oral Presentation
Keywords: Smackover, Jurassic, precession, facies architecture

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The Upper Jurassic Smackover Formation in the semi-restricted to restricted Conecuh Embayment of southwestern Alabama consists of three distinct carbonate factory types (microbial, skeletal, and abiotic) that provide a genetic record of sediment production and deposition in a mixed carbonate-evaporite-siliciclastic system. Sedimentary and geochemical proxy data from analysis of 29 cores indicate that the lower, transgressive interval of the Smackover Formation in the Conecuh Embayment consists of microbially dominated sediment that accumulated in an oxygen-depleted and nutrient-enriched environment, possibly associated with regional upwelling and propagation of internal waves. The upper, regressive Smackover Formation consists of microbial and oolitic facies in the more restricted part of the embayment and a cyclic repetition of two distinct associations of depositional and geochemical facies variants in the less restricted part of the basin. Cyclicity in the regressive Smackover likely records pulses of riverine water from bay-head deltas controlled by dry-wet climate cycles and supports the inference of high-frequency climatic cyclicity in the equatorial Late Jurassic. Time-series analysis of terrestrial influx proxies (titanium and aluminum) from a 90 m section of slabbed core in southwest Alabama demonstrates the occurrence of precession-scale cyclicity, supporting and extending previous observations on monsoonal conditions during the Middle and Late Jurassic. The climatic cycles of the Smackover likely resulted in a pronounced alternation of intense weathering and river discharge with a dry climate and enhanced evaporation. The periodic sediment influx and freshwater discharge into embayed, restricted environments played a major role in the Smackover's lateral and vertical geochemical and depositional heterogeneity and the deposition of slope-centered microbial carbonates.

Extension of results from this study should improve understanding of the influence of sea-water controls on microbial carbonate sediment production and accumulation, thereby enhancing the predictability of facies distribution in analogous settings.

Ordovician carbon cycle and sequence stratigraphy: insight from the St. Lawrence platform, Quebec

Oral Presentation
Keywords: carbonate cyclicity, carbonate depositional systems

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Carbon isotope trends in carbonate rocks record changes in the global carbon cycle, with large fluctuations commonly linked to global perturbations to the environment. In marine settings, the $\delta^{13}C$ trend reflects a complex interaction between global, regional, and local processes, including carbonate deposition, meteoric input, organic carbon, burial/oxidation, carbon sources and their fluxes, and local anoxia. These processes can be directly and indirectly be controlled by sea-level change, since it controls proximity to terrestrial sources, basin restriction, meteoric fluids circulation and carbonate production. It thus can enhance or mute Carbon isotope fluctuations. A practical approach to distinguish between local controls and global signals on regional $\delta^{13}C$ trends is to place the data within an age-calibrated, sequence stratigraphic framework.

The Ordovician records a series of coupled changes in Earth's biosphere and paleogeography, such as the Great Ordovician Biodiversification Event and the development of the Taconic Orogeny, on top of this the global climate transition from a warm to a glacial regime. The Ordovician $\delta^{13}C$ record preserves multiple excursions, but most are not well characterized globally and temporally, so their exact relationship to global events is uncertain.

We will present new Carbon isotope records from the Saint-Lawrence Platform (SLP), Quebec, developed within a new sequence stratigraphic framework for these strata. To distinguish between local, regional and global controls on the C isotope signal, and to investigate the relationship between sea level and $\delta^{13}C$, we examine the record at multiple sequence scales. We aim to place these results into the global $\delta^{13}C$ record of the Ordovician and geochronological framework based on radiometric dating of ash beds in the SLP, and to explore links between the Carbon isotope record and major Ordovician events such as the rise of terrestrial plants, the Taconic Orogeny, and the transition from a greenhouse to an icehouse Earth.

Pre-salt lacustrine reservoirs; new ideas and concepts for the structural evolution of the conjugate margin, lake hydrology and depositional models

Oral Presentation
Keywords: lacustrine, microbialite, carbonate, rift

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Cretaceous Pre-salt lacustrine reservoirs have been explored for the two decades, both along the Brazil Margin (Campos and Santos Basins) and the Angolan Margin (Kwanza and Benguela Basins). Exploration along the Angola margin in the late 2000's and recently along the outboard areas of the Campos and Santos basin (2020 to recent) highlights new findings and a need to re-assess the models for this play type.

Conjugate reconstructions and well data from the Brazil Campos Basin and the Angola Kwanza Basin reveal similar lake hydrology and carbonate facies, indicating a shared structural history. From early Barremian to Aptian when the basin evolved from a late rift phase to drift (Sag), the carbonates record alternating periods of restricted (high pH and salinity) lakes and more open and balanced lakes. The restricted lake phases resulted in microbial and oncolitic carbonates and Stevensite deposition, while the more balanced lakes deposited pelecypod-rich fauna indicating fresh to brackish water.

The carbonates vary with basin position, from siliciclastic input and stromatolite or mud flat deposition near lake margins to shrub and microbial textures on outer rift highs, within the hinge line. Away from rift highs, sediment is dominated by Stevensite and spherulites, indicating a quiet lake bottom. New well and seismic data show pre-salt intervals outboard of the hinge line thin onto an outer high (volcanic plateaus?) between the Angolan and Brazil basins, with silica replacement and mound-like structures. Wells results also indicate gas-prone fluids, suggesting volcanic activity and hot fluid circulation, possibly indicating an outboard high (volcanic origin) during the late Aptian and later rifting.

Carbonate deposition and facies is controlled by position within the basin (inside or outside the hinge line), the chemistry and hydrology of the lakes as the rift evolved, position relative to an outer (perhaps volcanic) high, and hot and cold springs discharging into the lake.

Sea-level and paleoenvironmental controls on thrombolite reef growth following rapid marine flooding of an epicontinental basin, basal Windsor Group (Mississippian), Cape Breton, Canada

Oral Presentation
Keywords: microbialites, Mississippian, reefs, thrombolite

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Interbedded carbonates and evaporites of the Windsor Group are the product of a pronounced and abrupt climatic, oceanographic, and geomorphologic transition caused by the Visean marine inundation of the Maritimes Basin in Atlantic Canada. The Windsor Group overlies widespread alluvial fan deposits of the Horton Group, deposited in half-graben and graben depocenters separated by uplifted basement blocks. The contact between alluvial deposits and shallow to deep-water marine carbonates is at least locally conformable, recording rapid basin flooding. Study of the basal Windsor carbonate deposits immediately overlying this surface offers unique opportunities to assess the interplay between tectonics, eustasy, and paleoenvironmental conditions on the nature of carbonate deposition during such a marked transition. In the onshore Sydney Subbasin of Cape Breton, the basal Windsor Group is represented by the Gays River and Macbeth Brook formations. Re-evaluation of diamond-drill cores and outcrops in the area have allowed identification of a largely unknown thrombolite reef complex. The reef complex's core is a series of overlapping patch to amalgamated rigid thrombolite(microbial), and subordinately stromatolite-coral, reefs and bioherms that are consistent with a global post-Fammenian shift towards microbial shallow-water buildups. Genetically associated inter-reef molluscan facies, peritidal peloidal and oolitic grainstones, and shallow subtidal photozoan communities are evidence of warm, supersaturated water and constrain the shallow paleoenvironmental context of these facies. In this study, detailed reconstruction of reef-growth using core, outcrop, and quarry walls informed correlations between and interpretations of the basal Windsor Group's sequence stratigraphy, reef growth, and the evolution of coeval off-reef facies. Together, these genetic interpretations provide greater constraints on the paleoenvironmental relationships between the thrombolite reefs, adjacent facies, and their responses to changing environmental conditions that are broadly applicable in the understanding of thromobilitic reefs throughout the Precambrian and Phanerozoic.

Carbonate-rich lacustrine systems—the Green River Formation, Western USA and the pre-salt of Brazil—chemistry and climate, shorefaces, microbes, and minerals

Oral Presentation
Keywords: OM-rich lacustrine, mixed systems

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Both biotic and chemical carbonate deposits occur in ancient lake systems and can contain significant hydrocarbon reservoirs in organic matter (OM)-rich systems. Despite being deposited in very different tectonic regimes – post-orogenic foreland for the Green River Formation (GRF), and syn-rift for the pre-Salt Brazil, lake depositional processes and chemical controls on carbonates are similar. Ion provenance and climate determine mineralogy.

Both the GRF and the South Atlantic lakes are OM-rich, alkaline lakes where pH values may have been as high as 10-12. Both lake systems were deposited under semi-arid to arid conditions and are thought to be relatively closed systems. Co-variance of C and O stable isotopes in the GRF and lack of spring deposits indicates a lake system dominated by surface inflow. The GRF is rich in Na, Ca, Mg, and HCO_3 resulting in precipitation of nahcolite, trona, calcite and dolomite. The South Atlantic rift lakes, fed by surface runoff and springs, are rich in Ca, Mg and Si resulting in formation of stevensite, calcitic spherulites, and dolomite.

Carbonate sediments common to both lake systems include littoral bioclastic coquinas, ooid grainstones, and microbial deposits. The GRF paleo-shoreline deposits range from dolomitic intraclastic packstone to oolitic and ostracod grainstones. The South Atlantic paleo-shorelines include molluscan and intraclastic lime rudstones and grainstones. Interparticle porosity dominates in both shorelines.

South Atlantic carbonates also include m's thick dolomitic spherulitic grainstones containing pseudo-fenestral porosity. In addition, spring deposits contain porous intraclastic breccias. The GRF microbial-rich units are characterized by m-scale cycles that are comprised of shallow water intraclastic rudstone/grainstone and oolitic grainstonesupportstones, overlain by microbialites that transition upward into OM-rich dolomitic mudstones. Intra-particle, interparticle, fenestral, and vuggy pore types are common resulting in excellent reservoir quality. Dolomudstones in lakeshore and profundal OM-rich environments contain microporosity.

Early marine microbial diagenesis in the Abu Dhabi Lagoon (UAE): field experiments and temporal quantification using CT-Scan and SEM

Oral Presentation
Keywords: early marine diagenesis, microbes, Arabian/Persian Gulf, SEM

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The integrity and resilience of shallow marine carbonate sedimentary systems, including coral reefs, shoals, and lagoonal environments, are heavily influenced by early marine diagenesis, particularly through sediment-microbe interactions. While microbial activity in reefs is well-documented, micro-bioerosion and

microbially mediated precipitation in loose carbonate sediments are less understood, mainly due to the complexities of sediment transport dynamics and challenges in tracking changes in carbonate grains from source to sink. To address these challenges, we conducted long-term field experiments by deploying epoxy resin blocks containing various types of carbonate sands (ooids, gastropods, mixed bioclasts, and foraminifera) in shallow subtidal zones of the Abu Dhabi Lagoon for six months. Using optical microscopy, SEM, and CT scanning, we compared the petrographic characteristics of the fixed sediment before and after field incubation, allowing us to quantify temporal changes in microbial infestation, microbioerosion, and precipitation across substrates and zones. Preliminary results reveal intense endolithic activity in all sand types near the outer lagoon's ooid shoals, with up to 25% available grain volume loss over 6 months, primarily driven by biogenic dissolution. In some cases, microborings contained radially growing aragonite needles (<1 micron long), indicating the crystallization of endolithic filaments and the development of cryptocrystalline microtextures. Conversely, sands from the middle lagoon, near mangrove zones, exhibited minimal endolithic activity, dominated by low-intensity, homogeneous dissolution. This study provides the first quantification of microbioerosion rates in carbonate sands from the arid, shallow marine environments of the Arabian/Persian Gulf. It also offers temporal insights into microbial activity in sediments, which are valuable for refining parasequences in ancient deposits and emphasizes the critical role of early microbial diagenesis in shaping carbonate grains before subsequent diagenetic processes and the formation of potential microporosity.

Stratigraphy and preservational variation of reef-building microbialites in the Tonian Reefal assemblage (Fifteenmile Group) of Yukon

Oral Presentation
Keywords: reefs, stratigraphy, microbialite, thrombolite

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Throughout much of Earth's history, reefs have been crucial components of sedimentary systems, due to their role as cradles of evolution and ecosystem engineers, and their significant influence on the global carbon cycle. While the evolution of Phanerozoic reef systems has been extensively studied, particularly in the context of the succession of metazoans that have contributed to reef construction, our understanding of temporal changes in reef morphology in the Proterozoic is relatively limited. For example, the Tonian period (1000–720 Ma) may represent a critical transition in microbialite reef construction, with the emergence of reefs built predominantly by thrombolites and other framework-constructing microbialites, but our understanding of this transition in reef evolution through time is limited by a sparse record of detailed case studies.

Here, we present a stratigraphic analysis of the ca. 850–800 Ma Reefal assemblage in the Ogilvie Mountains in Yukon, Canada. We find that this unit comprises a substantial, prograding platformal reef system, with alternating laminated and unlaminated microbialite building up on areas of uplifted paleotopography. In the adjacent depocentres, shale-to-carbonate sequences record periodic progradation and/or restriction.

Recrystallization and silicification heavily obscure primary growth features in the majority of Reefal assemblage microbialite outcrop. However, we identify consistent microbialite textures at three different stages of preservation, both in outcrop and in petrographic thin section. We infer that the Reefal assemblage is predominantly built by framework-building microbialite, with strong similarities to the approximately co-eval Little Dal Group of the Northwest Territories. The obliteration of microbialite textures in the Reefal assemblage has implications for the thrombolite record in deep time, as the sparse record of thrombolites in the Precambrian, particularly before the Neoproterozoic, may be a result of preservation-related obscurity rather than true absence.

Lithocodium presence in the Jurassic Arabian Plate carbonates: paleontological and diagenetic insights into enhancing reservoir quality

Poster Presentation
Keywords: lithocodium, Arabian Plate, Jurassic

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Jurassic reservoirs in the Arabian Plate are a key component of the region's oil and gas industry, with their quality being of paramount importance for exploration and production. Among the various factors influencing reservoir quality, the role of biogenic components, such as *Lithocodium*, which play a significant factor in Jurassic carbonate fabric production as well as reservoir quality enhancement. *Lithocodium* is a genus of coccoid algae that contributes to the formation of carbonates, particularly in reef and platform environments. This research explores the presence and significance of *Lithocodium* in the Arabian Plate's Jurassic reservoirs. By discussing its contribution to carbonate fabric production, it's role in diagenesis, and overall reservoir performance, we illustrate how this microalgae presence plays a crucial role in the diagenetic processes that enhance the storage capacity and fluid flow characteristics of the Jurassic carbonates. The study integrates petrographic, geochemical, and petrophysical data to highlight the influence of *Lithocodium* on reservoir properties and its implications for future exploration and production strategies.

Geochemical variations in the large benthic foraminifera *Sorites orbiculus* from a land-attached Red Sea lagoon, Saudi Arabia: potential proxies for monitoring environmental conditions in modern and ancient lagoons

Poster Presentation
Keywords: benthic foraminifera, biogeochemistry, paleoenvironment, biogenic carbonates

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Large benthic foraminifera (LBF) are common inhabitants of modern and ancient shallow-water carbonates, providing geochemical records for paleoenvironmental reconstructions. We executed a field-based analysis to correlate major elements (Mg/Ca, Sr/Ca) and stable isotopes (C^{13}, O^{18}) in LBF with temperature and salinity in a modern lagoon with diverse sub-environments to develop a predictive model of environmental variables. The aim is to better evaluate fossil outcrops and to develop an environmental monitoring method for modern lagoons facing anthropogenic developments.

Eight traps composed of an artificial grass square fixed on a substrate were placed in the Al Wajh lagoon (Red Sea, Saudi Arabia) together with conductivity/temperature loggers. Traps were replaced every 6–7 weeks, and CTD casts were taken for calibration. Live specimens of LBF *Sorites orbiculus* were picked, cleaned and digested in 0.075M HNO_3. Mg/Ca and Sr/Ca were analyzed using an ICP-MS. C^{13} and O^{18} isotopes were measured at the Stable Isotope Laboratory (University of Miami).

Mg/Ca ratio ranged between 130–180 mmol/mol (lowest values reported in January at water temperature of 19.8°C, and highest values in September at water temperature of 34.3°C). Sr/Ca ratio ranged between 2.2–2.6 mmol/mol, with a less pronounced seasonal trend. Salinity was high throughout the lagoon ranging from 40 to 45 ppt, with the highest range in the more isolated southern section.

The analysis showed a strong trend between the major elements and temperatures, however with no significant correlation to salinity. Mg/Ca ratio was lower than the same foraminifera Family (Soritidae) in the Indian Ocean, while Sr/Ca ratio was twice higher than the one reported within the family. Forthcoming results from trace metals and stable isotope measurements will provide a unique dataset for calibrating environmental parameters and the impact of water circulation in the lagoon providing both insights for environmental monitoring and interpretation of fossil foraminiferal data.

From the intertidal to the aphotic—microbes are a ubiquitous and essential component of lithifying carbonate platforms in the Red Sea

Poster Presentation
Keywords: microbes, cementation, environment, Red Sea

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Microorganisms are ubiquitous on Earth, and their activities are increasingly recognized as pivotal in shaping the surface of our planet. In the Red Sea, the geomicrobiological process of microbially-induced carbonate precipitation contributes significantly to the shaping and lithification of carbonate platforms. We explore the manifold environments of microbial cementation on the Al Wajh carbonate platform and the microbial communities leading to lithification.

An extensive field campaign over 2 years produced hundreds of rock and sediment samples. Samples were analyzed via thin-section petrography, SEM, XRD, and DNA metabarcoding of the inhabitant microbial communities. In addition, a wide array of environmental data such as pH, salinity, temperature, carbonate saturation and the tidal range were collected with the help of permanently deployed loggers, mobile multi-tools and water samples.

Microbial communities living in sediments bind individual grains together by colonizing pore spaces and producing extracellular polymeric substances (EPS). This initial stabilization stage transitions to cementation via carbonate precipitation as cell membranes and EPS are ideal nucleation sites. Typical features are early micritic rims and meniscus cements—often composed of high Mg calcite and aragonite.

These micritic features are observed in almost every carbonate environment of the Red Sea including intertidal stromatolites, beachrocks, polygonal tepee structures, calcifying microbial mats, subtidal hardgrounds and sediment crusts forming at the aphotic/mesophotic platform flanks. In these environments, microbially induced carbonate precipitation is massive, promoting platform lithification and representing an important CO_2 sink. The combination of microbial activities, oligotrophic waters and high carbonate mineral saturation reaching ΩAragonite >3.5 deliver ideal conditions for carbonate precipitation. An investigation of the microbial communities and their functionalities is ongoing.

A first comprehensive investigation of microbially induced cementation processes in the Red Sea reveals that microbes play a fundamental role in the lithification of Red Sea carbonate platforms, likely contributing to their preservation and steep margins.

Impact of sea-water chemistry on carbonate sediment production and stratigraphic architecture of progradational microbial-oolitic carbonate margins

Poster Presentation
Keywords: carbonate factories, slope microbialite, oolite, facies architecture

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Carbonate factories are defined by distinct depth ranges where carbonate sediment is produced biotically or abiotically, and differ in composition and production rates. Carbonate factories are influenced by the oceanographic setting and affect the facies architecture through a complex interplay of various space- and time-dependent dynamics. Two analogous sedimentary systems are compared herein, the Lower Triassic of the Nanpanjiang Basin in south China and the Upper Jurassic of the Eastern U.S. Gulf Coast, both consisting of prograding carbonate shelves with microbialite-dominated slopes and oolitic margins. The Lower Triassic example displays a continuous exposure through interior, margin, and slope depositional environments, providing exceptional information on the facies architecture. The Upper Jurassic example is an exclusively subcropping unit that has been documented through a wealth of log, core, and seismic data.

Integrated sedimentary and geochemical proxy data indicate that carbonate sediment production and accumulation in microbial-oolitic carbonate systems occur in semi-restricted basins and are controlled by changes in ocean circulation and variations in the chemical and physical stratification of the water column. The spatial and temporal activation of different carbonate factories in both examples indicates a strong oceanographic control on the location and type of carbonate sediment production and on the distribution of depositional facies. Microbial carbonates in slope environments form in dysoxic and mesotrophic to eutrophic conditions, whereas skeletal and abiotic production prevails in more oxygenated and nutrient-depleted environments with moderate terrestrial input.

Numerical modeling indicates that slope microbialite production adds to the volume and the stability of the slope through in-situ growth of stabilized material and is responsible for enhanced progradation of the shelf. Increased oolite production rates do not impact the large-scale architecture of the shelf because the systems are accommodation-limited, and any excessive production is either shed basinward or accumulated locally to form islands.

Exploring the mesophotic geomorphologies of the Saudi Arabian Red Sea continental shelf

Poster Presentation
Keywords: geomorphologies, Red Sea, seafloor, mesophotic

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The Red Sea features a large variety of shallow-water carbonate depositional systems, including fringing reefs, barrier reefs, and small atolls. Although satellite images reveal their distribution and geomorphology in depths of less than 30 meters, much of the deeper continental shelf remains largely unexplored. To bridge this observational gap, we integrated extensive bathymetric datasets from various sources covering the Saudi Arabian Red Sea margin, focusing on the geomorphologies of the mesophotic and shallow aphotic zones (30–300 meters depth). Our preliminary results highlight significant geomorphological variability in the southern Red Sea. Around the Farasan Islands, the 100-kilometer-wide continental shelf is mainly mesophotic (50–80 meters) and characterized by kilometer-scale blocks interspersed with narrow, linear, and deep (>300 meters) mini-basins. Here, the mesophotic surfaces display chaotic morphologies suggesting karstification, featuring circular or coalescent depressions (110–160 meters deep) and ribbon-like structures rising to depths of 40–50 meters. In contrast, further north, the mesophotic shelf is limited to just a few kilometers near the main coast, leaving the reefs of the Farasan Banks isolated by depths greater than 200 meters. This study offers the first comprehensive overview of the Red Sea's continental shelf geomorphology beyond the euphotic zone. It supports previous findings emphasizing the importance of sub-seafloor salt tectonics and sea-level in shaping carbonate systems in young rifted margin settings. Additionally, it provides valuable insights into paleo- and prehistoric coastal landscapes characteristic during lowstand periods and their implications for human dispersal out of Africa. It also paves the way for future exploration of the Red Sea's mesophotic depths and their largely unexplored ecosystems.

Characterization of thrombolites in the Huns platform of the Nama Group, Namibia

Poster Presentation
Keywords: thrombolites, petrography, geochemistry

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Microbialites are organosedimentary carbonate structures that are formed due to the activities of microorganisms in mineral-saturated aqueous environments. When fossilized, they provide valuable indicators within the ancient geological record of past environmental conditions and biological activity. Thrombolites, a type of microbialite, have internal textures that are characterized by mm to cm-sized mesoclots. However, the usage of the term 'thrombolite' within the literature varies depending on the author. In southern Namibia, the late Ediacaran middle Nama Group is characterized by a series of thrombolite-dominated patch reefs, and other thrombolite facies, deposited in a restricted sedimentary basin. In the Huns platform of the Witputs sub-basin, thrombolites with different morphologies have been observed on a macroscopic scale and are described according to their apparent clot size. Differences in thrombolite morphology are believed to be linked to water depth, such that stratigraphic changes in morphology should track sea level change across the platform over time. In order to better characterize these thrombolites, reef facies across the sub-basin will be collected within a sequence stratigraphic framework and examined using petrographic, SEM, carbon/oxygen isotope, and elemental analyses. These data will allow us to begin to establish the range of geochemical and petrographic characteristics of the thrombolites, better-define the thrombolite facies, and potentially link these observations to the sequence stratigraphic evolution of both the Huns platform and Witputs sub-basin. More broadly, these results will help establish a more systematic framework for defining thrombolites and interpreting their paleoenvironmental significance. Here I will present my preliminary results from the 2025 field season.

Diatoms diminish dolomite

Poster Presentation
Keywords: carbonate diagenesis, dolomitization

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Sedimentary dolomite is abundant in earth history, but rare in Cenozoic and modern carbonate sediments. Although modern seawater contains high concentrations of Mg and Ca in molar ratio of ~50 mM / 10 mM, modern carbonate sediments are dominated by aragonite. Our laboratory syntheses and molecular dynamics modeling results demonstrate that the dissolved silica (with concentrations of ~ 1 mM to 2 mM) can catalyze dolomite precipitation. Primary dolomite in the Great Salt Lake in Utah and Deep Springs Lake in California are correlated with concentrations of dissolved silica in the lake waters. Molecular dynamics modeling shows that adsorbed $Si(OH)_4$ can promote surface water removal and carbonate anion binding to surface Mg cations, which is an important step for dolomite growth. The dramatic drop in dolomite abundance in late Cretaceous is a result of global radiation of diatom that lowered the concentration of dissolved silica in seawater globally.

In earth history, massive dolomite formations in rock records correlate with global high CO_2 levels. Our study shows that strong chemical weathering of silicate rocks like basalts promotes dissolved silica input into paleo-ocean besides metal cations like Ca, Mg and Na. Geochemical modeling of the Marinoan cap dolomite formation (~635 million years ago) after the deglaciation of the snowball earth shows that cap dolomite and silica (chert) bands precipitation were no isolated events, but rather the silicate weathering was the determining factor for the appearance of cap dolomite. Understanding the dolomite problem and carbon cycles in earth history can help us to solve the challenge CO_2 problem we are facing today.

Tuesday
12 August 2025

Oral and Poster Presentations

Late Permian Zechstein carbonates of the Utsira High, Norwegian North Sea

Oral Presentation
Keywords: Late Permian, carbonate–evaporite systems, dolomitization/dedolomitization, dissolution

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The Utsira High is a prominent basement high located in the NE part of the Norwegian North Sea, consisting predominantly of weathered Palaeozoic granitoids with a thin Mesozoic sediment cover. Locally, eroded remnants of an extensive Zechstein (Late Permian) carbonate shelf are preserved in halfgrabens. The preserved Zechstein succession is up to approximately 100 m thick and mainly consists of the Z1 and Z2 lithological cycles which constitute the primary Zechstein reservoirs in the North Sea.

Core observations from the Symra discovery and the nearby Johan Sverdrup field suggest that the Zechstein carbonates underwent penecontemporaneous, reflux-type dolomitization followed by later dolomite recrystallization, calcitization/dedolomitization and karstification. Reservoir quality is linked to a combination of depositional facies and post-depositional meteoric diagenesis, with the best reservoir properties observed in recrystallized dolo-grainstones. Dolomite recrystallization is interpreted to have occurred during long-term subaerial exposure in the Late Triassic, with a near-surface origin proposed for the recrystallized dolomites. Porosity enhancement occurred contemporaneously with the recrystallization process. On the micro-scale the dissolution of both $CaSO_4$ cements and metastable dolomite phases is observed. The enlargement of existing pores locally resulted in the development of vuggy porosity. On the macro-scale, solution-widened fractures and fault planes play an important role as they enhance reservoir connectivity and represent drilling hazards.

At Johan Sverdrup field, prolonged subaerial exposure seems to have resulted in the dissolution of a topmost Z2 evaporite sheet, resulting in the dedolomitization of the underlying Z2 carbonates and significantly reducing matrix porosities.

Having presented earlier results on the Utsira High Zechstein at the Mountjoy I, we want to give an update, integrating new data from recent wells. We will illustrate the evolution of the Utsira High Zechstein reservoirs from deposition through diagenetic processes into their present role as hydrocarbon reservoir, highlighting key processes for reservoir characterization, connectivity, and quality.

Aragonite neomorphism, aragonite-calcite seas and pCO_2

Oral Presentation
Keywords: aragonite neomorphism, aragonite-calcite seas, pCO_2

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Carbonates have dogmas that perpetuate with little or flawed data. This presentation will discuss two, aragonite neomorphism and aragonite-calcite seas, both of which could be caused by variations in pCO_2. Aragonite neomorphism by thin films has been dogma for almost 50 years. The product of "aragonite neomorphism" is generally sparry calcite with partial preservation of internal wall structure. Theoretically, alteration along thin films involves aragonite dissolved on one side of a migrating film and calcite being precipitated on the other due to aragonite being more soluble than calcite. Pleistocene carbonates in Enewetak, the Bahamas and Yucatan are mixtures of aragonite and low-magnesium calcite (LMC); hence, the transition is in progress, and calcitized (neomorphic) aragonite is common. Microporous aragonite with substantial intrafabric dissolution is widespread and commonly adjacent to or surrounding neomorphosed aragonite. Geochemistry of the neomorphic spar is similar to freshwater calcite cements and very different from the aragonitic precursors. These observations support aragonite neomorphism by partial intrafabric dissolution of aragonite followed by calcite precipitation, resulting in neomorphic spar. Changes in carbonate saturations are caused by variations in pCO_2 of meteoric waters.

Phanerozoic oceans alternated between dominantly aragonite and calcite. Variations in oceanic Mg/Ca ratios are proposed to explain with support from lab work on mineral solubilities and Mg/Ca ratios of aqueous inclusions in ancient salts. Pleistocene and Neogene carbonates show a transition from aragonite precipitation in shallow seawater to aragonite dissolution with LMC precipitation in deeper seawater. Greater pCO_2 with depth increases solubility and causes precipitation to change to LMC with no change in Mg/Ca ratios. Mg/Ca ratios in inclusions in salt would not reflect oceanic ratios because Mg/Ca ratios change dramatically during evaporation of seawater. Recent studies show that pCO_2 can change ocean saturations, and in the Phanerozoic, variations in pCO_2 could have changed dominant marine carbonate mineralogy.

A new method for reconstructing hydrocarbon accumulation history of deep to ultra-deep carbonate reservoirs

Oral Presentation

Keywords: deep to Ultra-deep, hydrocarbon accumulation history, carbonate minerals, laser U–Pb isotopic dating

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The fluid inclusion homogenization temperature method is the most widely used approach for reconstructing hydrocarbon accumulation history in deep to ultra-deep carbonate reservoirs. However, there are three major limitations: (1) The difficulty in restoring the eroded thickness of target strata, leading to uncertainty in the reconstruction of tectonic-burial history. (2) It is commom to use the brine inclusion homogenization temperature as a substitute for hydrocarbon inclusion trapping temperature. However, it is often challenging to find coexisting hydrocarbon and brine inclusions within the same host mineral. (3) It is difficult to determine the trapping time based on the trapping temperature. As in multi-cycle superimposed basins, the same trapping temperature may correspond to multiple ages on the tectonic-burial history curve, resulting in non-unique solutions.

The application of laser U-Pb isotopic dating of carbonate minerals and clumped isotope thermometry has addressed these limitations and led to the development of a new method for reconstructing hydrocarbon accumulation history in deep to ultra-deep carbonate reservoirs. (1) Restoration of the eroded thickness of strata is achieved through multi-phase diagenetic mineral age-temperature constraints, effectively resolving the uncertainty in the tectonic-burial history reconstruction. (2) Direct measurement of hydrocarbon inclusion trapping temperature, overcoming the challenge of determining trapping temperature when no coexisting brine inclusions are present in the host mineral. (3) Direct measurement of hydrocarbon inclusion trapping time, addressing the issue of non-uniqueness in accumulation ages for multi-cycle superimposed basins.

This method has been applied to reconstruct the accumulation history of natural gas reservoirs in the Dengying Formation of the Sichuan Basin. This method has significantly higher accuracy and success rates compared to the fluid inclusion homogenization temperature method.

Pore to core plug scale characterization of porosity and permeability heterogeneities in a Cretaceous carbonate reservoir using laboratory measurements and digital rock physics, Abu Dhabi, United Arab Emirates

Oral Presentation
Keywords: limestone reservoirs, digital rock physics, multi-scale, porosity, permeability

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Laboratory and digital rock physics study of a Cretaceous limestone reservoir in Abu Dhabi, United Arab Emirates, provides insights into pore connectivity, pore-throat size, and permeability distributions. The procedure involves core analysis at different scales using micro-computed tomography, scanning electron microscopy, and nano-computed tomography; porosity quantification using segmentation techniques; numerical simulation of permeability using lattice Boltzmann method; and upscaling simulation results to core-plug scale using Darcy's Law. The greater proportion of connected versus poorly interconnected pores is attributed to (i) the formation of early diagenetic grain-rimming calcite cement, which reduced the degree of mechanical compaction and pore-throat size reduction, (ii) limited introduction of carbonate mud by bioturbation due to rapid sediment burial, and (iii) dissolution of allochems and partial dolomitization of micrite matrix. Microbial micritization of allochems at the seafloor led to the transformation of grain-supported limestones, dominated by unimodal macropores, into reservoirs with multimodal porosity. Conversely, the mud–supported limestones have depositional unimodal micropore distribution, which is reduced by mechanical compaction and cementation by calcite micro-overgrowths around micrite particles. Good agreement between laboratory and simulated values suggests that lateral facies and related textural variation across different depositional environments have limited implications for digital rock physics techniques in predicting the petrophysical properties of limestone reservoirs. Nevertheless, careful selection of representative elementary volume within a geologic context for a complex, anisotropic limestone reservoir is the key to achieving reliable results.

Human-induced diagenetic alterations in fine-grained carbonates driven by seawater flushing: Tor Formation, Chalk Group, Danish North Sea

Oral Presentation
Keywords: chalk, water flooding, diagenesis, geochemistry

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We document diagenetic alterations caused by injection of deoxygenated seawater into a chalk reservoir in the Danish North Sea. The changes are recognized by comparing drill core samples from equivalent reservoir zones in well Nana-1XP well, drilled prior to water flooding, and well HDA-19, drilled after fourteen years of intense and continuous water flooding. Based on SEM petrography combined with major and trace element analysis, and stable isotope analysis ($\delta^{18}O$ and $\delta^{13}C$), we show that extensive waterflooding with deoxygenated seawater has modified the original chalk fabric. The Tor Formation chalk is predominantly composed of mud-sized carbonate particles, consisting of low-magnesium calcite (LMC) microcrystals, coccoliths and their fragments, with minor contributions of coarser biotic carbonate allochems, clay, and silica. This fabric is interpreted to reflect a two-step diagenetic pathway involving initial mechanical compaction followed by limited chemical compaction, which is typically observed in hydrocarbon-charged chalk reservoirs elsewhere in the region. In addition, the waterflooded chalk from well HDA-19 represents a modified chalk fabric where seawater flooding has triggered notable dissolution features, evidenced by solution pits and etched surfaces on carbonate crystals, precipitation of irregular to rounded clusters of carbonate microcrystals, subtle changes in $CaCO_3$ weight%, enrichment of Mn and depletion of $\delta^{13}C$ values. Geochemical data indicate Mn enrichment in water-flooded zones, reflecting the influx of Mn-rich seawater into a reducing burial environment. Slight Sr depletion and $\delta^{18}O$ enrichment in lower part of the reservoir suggest dissolution and recrystallization processes driven by cooler, $\delta^{18}O$-enriched modern seawater (annual average ~10°C). In contrast, Sr enrichment in the upper part of the reservoir is consistent with the formation of new microcrystals, including observed vaterite micro-crystals. $\delta^{13}C$ isotopic values show depletion across the entire water-flooded succession, aligning with enhanced porosity and permeability. This depletion suggests isotopic exchange with modern, isotopically lighter seawater during recrystallization, dissolution, and reprecipitation processes. Collectively, these data document the effects of human-induced diagenetic alterations in a fine-grained carbonate reservoir.

Evolution of diagenesis and reservoir quality in Brazilian pre-salt resedimented carbonate rocks from the Santos Basin

Oral Presentation
Keywords: lacustrine carbonates, resedimented deposits, diagenesis, pre-salt reservoir

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The South Atlantic pre-salt carbonate deposits are one of the largest hydrocarbon provinces in the world. The resedimentation of the *in situ* calcite aggregates and magnesian clay deposits created thick packages of calcarenites and calcirudites in the Santos Basin, eastern Brazilian margin. This study aimed to characterize the diagenetic processes, distribution patterns, and their impact on reservoir quality of resedimented deposits of Aptian Barra Velha Formation. Dolomitization and silicification are the main diagenetic processes. Blocky and saddle dolomite occur filling interparticle pores, and less commonly, replacing intraclasts. Locally, pseudomorphic dolomite preserved the original internal textures of the intraclasts. Interparticle and vugular pores are lined by prismatic quartz and filled by drusiform and coarsely-crystalline quartz. Chalcedony is present as fibrous rims and spherulitic aggregates both cementing and replacing grains. Microcrystalline quartz preferentially replaces intraclasts. Diagenetic calcite is less common and occur as rims lining and locally filling pores. Hydrothermal activity precipitated extensive silicification, barite, and dawsonite, and intense fracturing erased the primary features. Unlike the associated *in-situ* reservoirs, the porosity of the resedimented reservoirs was strongly reduced by mechanical and chemical compaction. Diagenetic processes reduced, preserved or increased the porosity. Blocky dolomite cementation was less deleterious to reservoir quality compared to silica cementation, as it

preserved intercrystalline porosity between dolomite rhombohedrons. Understanding the patterns and impacts of post-depositional alterations on the pre-salt resedimented rocks will contribute to mitigating exploration risks and provid important insights into particulate carbonate rocks deposited in lacustrine and alkaline environments.

Geothermal carbonate reservoirs—exploiting a karstified carbonate reservoir in the North Alpine Foreland Basin, Germany

Oral Presentation
Keywords: carbonate reservoir, karst, geothermal

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Geothermal energy is increasingly seen as a vital part of the 'energy transition', especially to cover the demand for direct heating. Except for active volcanic areas, deep carbonate aquifers host what are probably the most important geothermal resources in the world. Stadtwerke München (SWM), the local energy supplier in Munich, and other players in the area have drilled close to 50 geothermal wells with a success rate exceeding 90% that underscores their sustainable production capabilities.

The primary exploration target in this region are the carbonates of the Upper Jurassic Malm reservoir buried some 2-4 kilometers by the alpine foreland basin sediments. The interval, which is up to 600 meters thick, contains numerous different lithofacies, some of which can also be identified in 3D seismic volumes. Lithofacies types range from massive biohermal structures to layered basin and lagoon deposits, coupled with structural elements such as karstic fractures and faults.

Internal heterogeneities as well as the sequence stratigraphic architecture have significant impact on reservoir type and properties. Highest flow rates (>>100L/sec) are often associated with karstification in addition to the primary matrix permeability. The comparison between measurements from core data and well tests provide evidence of the reservoir's excess permeability, exhibiting values several orders of magnitude higher than those measurable in cores. Dolomitization, faulting and fracturing play a more minor role. Like in hydrocarbon reservoirs, permeability and permeability heterogeneity is key to understanding the reservoir performance. The stratigraphic record suggests that karstification occurred during the Jurassic and Cretaceous, prior to the burial of the carbonates by the sediments of the alpine Molasse Basin.

The development around Munich highlights how technology and lessons learned from more than a century of discovery, appraisal and development in oil and gas have enabled the success of the geothermal industry in the region.

Petrographic characteristics of Friktia onyx marble, northeastern Algeria

Poster Presentation
Keywords: Friktia, onyx marble, fabrics

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The Constantine region hosts several occurrences of onyx marble, typically found in small veins often associated with karst cavities. These cavities are known for their Pb-Zn mineralization, as observed in the Felten-Ouled Sellem massifs. However, in Sidi Roumane, Sekkoum, and Friktia, onyx marble occurs as isolated deposits or with very little mineralization. This study focuses exclusively on the onyx marble from Friktia, presenting a preliminary petrographic analysis.

The dominant structure is banded, frequently accompanied by massive and occasionally dendritic structures. Texturally, the onyx exhibits stubby and elongated columnar fabrics, open textures, as well as microcrystalline and granular features. X-ray fluorescence (XRF) analysis reveals a high CaO content, averaging 98%, with MgO values ranging from 0.4% to 0.99%, and SO_3 concentrations between 0.7% and 1.99%. These compositional characteristics are expected to influence the physico-mechanical properties of the material, guiding its potential applications. Furthermore, this study provides a foundational dataset for paleoenvironmental and paleoclimatic reconstructions.

Development and application of new technologies of trace element testing for carbonate minerals

Poster Presentation
Keywords: trace element, laser ablation mapping technology, reconstruction of diagenetic environments

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Trace elements are widely used in tracing diagenetic fluids and reconstructing diagenetic environments. The wet method is a mature and commonly used measurement method, but the method encounters difficulties: high demand for powder samples, complex chemical processing procedures, and lower accuracy, which restrict the promotion and application of this technology.

We developed new technologies for testing trace elements in carbonate minerals and achieved three results. (1) The upgrade of wet method of trace element testing technology for carbonate mineral and optimization of chemical treatment process have reduced the demand for powder samples from 50mg to 10mg, meeting the requirements of microstructure sampling and testing. The acid consumption reduced from 10mL to 2mL, and the relative error of data has been reduced from 5–10% to 2–5%; (2) A new technology for trace element laser ablation imaging has been developed based on the RESOlution laser ablation system, iCAP TQ triple quadrupole inductively coupled plasma mass spectrometer, and QuadLock device. The detection limit has been reduced from 5–10 ppb to sub-ppb, the spatial resolution of the image has been increased from ≥5μm to ≤1μm, and the processing time has been improved by 10 times; (3) The new technology of trace element laser ablation imaging has expanded its application fields. In addition to micro-area fluid tracing and diagenetic environment reconstruction, it can also be used for laser U–Pb isotope age determination to improve the success rate and accuracy of dating. It is used for the study of the coupling relationship between trace element concentration (or ratio) and mineral cathodoluminescence characteristics, clarifying new cathodoluminescence control elements other than Fe and Mn.

The development of new testing technologies for trace element provides a powerful tool for the study of carbonate reservoir formation.

Zebra textures in fault-controlled, hydrothermal dolomite bodies: coupled mechanisms of replacement, deformation, and cementation

Poster Presentation
Keywords: hydrothermal dolomite, geomechanics, tensile failure, geochemical modeling

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Fault-controlled, hydrothermal dolomitization involves the interaction of high pressure (P), high temperature (T) fluids with the surrounding host-rock. A striking feature of hydrothermal dolomite bodies is the pattern development and periodicity of zebra textures, whereby alternating units of replacement dolomite (RD) and saddle dolomite (SD) form symmetrical RD-SD/SD-RD patterns. Zebra textures are often considered to be diagnostic of these elevated P/T conditions, but the roles of mechanical deformation and the localization of strain during dolomitization have received limited attention. Here we evaluate the effect of P/T perturbations on the genesis of zebra textures, alongside how strain-hardening mechanisms promote their characteristic pattern development. Published fluid inclusion homogenization and carbonate clumped isotope temperatures were compiled from the literature and the offset between these data were used as a geobarometer. Based on these pore-fluid pressures, a series of rock deformation experiments were conducted to reproduce zebra textures in the laboratory. Cylindrical rock samples were held in an annealed copper jacket and deformed in axisymmetric extension. As the rock underwent tensile failure, the copper jacket locally deformed by intracrystalline plasticity, strain-hardened, and stabilized each opening-mode fracture. As a result, a succession of closely spaced fractures formed along the length of the sample. In natural geological settings, an analogous process is inferred, whereby dilatancy hardening, precipitation hardening, and the stress shadow effect promote the rhythmicity that is a defining feature of zebra textures. Lastly, the effects of P/T perturbations on the solubility of dolomite were evaluated using the Pitzer aqueous model in PHREEQC. This interdisciplinary study presents novel insights into the geomechanical and hydrochemical interaction between metasomatic fluids and carbonate rocks, which are of critical importance to our understanding of carbonate-hosted ore deposits in sedimentary basins worldwide.

Fluid activities and reservoir forming mechanisms associated with strike-slip faults: a case study of Ordovician in Fuman area, Tarim Basin, Northwest China

Poster Presentation

Keywords: fluid activity, carbonate reservoir, strike-slip fault, Tarim Basin

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The complex fluid activities accompanying strike-slip fault movements play important roles in the formation of carbonate reservoirs and oil and gas accumulation. Taking Fuman area in Tarim Basin as an example, the strike-slip fault related reservoirs contain huge oil and gas reserves, and show strong heterogeneity, which seriously restricts the exploration and development. Based on the integrated analysis of structural geology, U-Pb dating, clumped isotopes, and inclusions, the strike slip fault activity periods, fluid properties, and oil and gas filling periods in the Fuman area have been studied. The results include: (1) The strike slip fault in the Fuman area is the result of multi-stage superimposed transformation of the Early Caledonian, Late Caledonian, Early Hercynian, Late Hercynian, and Yanshanian periods; (2) The active and calm periods of strike slip faults control fluid activity. The fault activity in the late Caledonian and late Hercynian periods induced strong hydrothermal activity, accompanied by local enrichment of silicon rich fluids and large-scale oil and gas injection, resulting in local dissolution and end metasomatism of reservoirs caused by hydrothermal activity; During the calm period after the fault activity period, meteoric water extends southward from the uplift area and undergoes a transition from dissolution to filling along the transport path; (3) The multi-stage and phased evolution of faults, fluid dissolution-precipitation transformation, and multi-stage oil and gas charging jointly lead to differential enrichment in different fault zones and segments of the Ordovician in the Fuman area. In a word, the fluid type and temperature and pressure conditions induced by strike slip fault activity are the key to determine the effect of fault activity on reservoir reconstruction, and have important guiding significance for the related fields of similar strike slip faults in Tarim Basin and other counterparts.

The equipment innovation of dissolution modeling and its application on porosity formation and preservation in deep-buried carbonate

Poster Presentation

Keywords: deep to ultra-deep carbonate, simulation experimental device, pore-throat structure evolution, pore development and distribution

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In response to the bottleneck problem that the existing simulation experimental devices cannot meet the research needs of pore formation and preservation mechanisms of deep to ultra-deep carbonate rocks, a high-temperature and high-pressure visualization simulation experimental device for ultra-deep cross-tectonic-periods carbonate reservoir, which is featured by the functions of “annealing depressurization”, “visualization”, “high temperature (300℃) and high pressure (150MPa)”, and “real-time online detection of permeability and fluid (compositions and contents) was developed, providing a useful tool for conducting carbonate dissolution-precipitation simulation experiments under the conditions of mimic real geological background in deep to ultra-deep realm. Using the new device to conduct simulation experiments, three aspects of geological understanding were obtained: (1) rock-fabric and initial pore-throat structure play an important role in the evolution of pore-throat structure during dissolution process, which exhibit two different pathways of pore-throat structure evolution; (2) the potential for vug development of dolomite in deep to ultra-deep open flow systems is greater than that of limestone, and is controlled by type and concentration of acidic fluids, initial porosity and permeability. The vuggy pores can be formed continuously in deep to ultra-deep realm and mainly follow the pre-existing porous zone; and (3) in a nearly closed diagenetic system, after the chemical reaction between acidic fluids and carbonate rock reaches saturation and dynamic equilibrium, neither secondary dissolution vugs are formed nor pre-existing pores are destroyed, leading to the preservation of pre-existing pores. Tectonic uplift and decrease of temperature and pressure cause the precipitation of carbonate minerals from saturated solutions and the destruction of pores. The above understandings have important guiding significance for the evaluation of pore throat structure and development potential, main controlling factors and distribution of prediction of deep to ultra-deep high-quality carbonate reservoirs.

Wednesday
13 August 2025

Oral and Poster Presentations

A core-based assessment of the Leduc Formation carbonates in central Alberta, a prime candidate for CO_2 sequestration

Oral Presentation
Keywords: Leduc Formation, carbon sequestration, sequence stratigraphy, dolomitization

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The Leduc Formation and its equivalents in the Canadian Rockies have been the focus of various avenues of research for many decades. Dr. Mountjoy and his students established many essential elements of understanding, from depositional systems to the fundamental importance of dolomitization in subsurface examples—the latter being a critical factor for understanding these complex reservoirs. While Leduc reservoirs have a long history of hydrocarbon production, many of these buildups are now in stages of abandonment or enhanced-oil-recovery schemes. These buildups are now considered prime candidates for carbon sequestration in central Alberta. Additionally, these reservoirs have also seen interest from the perspective of lithium in brines, wastewater disposal, and geothermal applications.

The emerging applications for this legacy reservoir require an understanding of the Leduc in its entirety, which is commonly greater than 250 m thick. Many of the hydrocarbons pooled within the upper few tens of metres, resulting in a less-well established depositional framework for the downdip saline-aquifer portions of the buildups. Moreover, much of the well-established frameworks, including 3rd and 4th order sequence stratigraphic studies, have focused on the well-preserved limestone buildups and less so on their dolomitized counterparts due to the fabric-destructive nature of the dolomitization process. While the dolomitization has generally enhanced reservoir quality, it can also inhibit our ability to recognize primary fabrics, potentially hampering our full understanding of the Leduc's depositional architecture. Recent work by the Alberta Geological Survey aims to establish a facies framework within the dolomitized buildups based on cores, as well as place these facies assemblages into the established 3rd and 4th order sequence stratigraphic subdivisions that are known from limestone examples. Importantly, along with porosity typing, this work will help to better understand these complex buildups from the perspective of reservoir quality and flow units, helping to support new forays into this legacy reservoir.

CCS in fine-grained carbonate reservoirs—experiments, petrography, and modeling of the Chalk Group, Danish North Sea

Oral Presentation

Keywords: subsurface CO_2 storage, supercritical CO_2 injection, fluid–rock interaction, carbonate diagenesis

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This study examines the interaction between fine-grained carbonate reservoirs (chalk) and supercritical CO_2 ($scCO_2$), focusing on samples from the Maastrichtian Tor Formation from the Halfdan Field, Central Graben, Danish North Sea. Chalk reservoirs are likely to be susceptible to dissolution and, possibly, reprecipitation due to carbonic acid formed by the reaction of CO_2 with brine which can affect reservoir properties, fluid flow dynamics, and storage efficiency. This project integrates SEM petrography, geochemical experiments, $scCO_2$-core flooding experiments, and numerical modeling to elucidate dissolution and reprecipitation dynamics and their influence on fine-grained chalk reservoirs. Pre- and post-CO_2 injection CT scanning, SEM, and XPS-analyses are employed to characterize the core's overall structure, fabric, texture, and surface composition to evaluate variations that may potentially influence fluid flow dynamics and storage capacity. Batch reactor experiments under reservoir conditions, with varying brine composition and $scCO_2$ are used to evaluate reaction rates and lithological changes attributed to fluid-rock interactions. Approximately 15 batch experiments will allow determination of chalk solubility constants after being in contact with $scCO^2$ and brine. Geochemical modeling suggests divalent cations (e.g., Ca, Sr, Mn, and Fe) released during calcite dissolution may form secondary carbonates. These cations, along with stable isotopes ($\delta^{18}O$ and $\delta^{13}C$), serve as effective tracers to monitor dissolution and reprecipitation processes. Pressure fluctuation experiments will be performed to explore calcite solubility, episodic dissolution, and reprecipitation. Flooding experiments will simulate $scCO_2$ injection and fluid flow through chalk at reservoir conditions. Two experiments are carried out to compare the effects of continuous versus cyclic injection. Key outcomes will include evaluation of carbonate dissolution, recrystallization, and reprecipitation, analyzing their spatial distribution, and understanding their impacts on reservoir modeling. This research advances the understanding of human-induced diagenetic processes in low-permeability fine-grained carbonates and integrates experimental and modeling data to develop sector-scale numerical models to evaluate the feasibility of CO_2 storage in these reservoirs.

An overview of the Devonian analogue investigation—revisiting the Devonian of western Canada with 3D digital outcrop models

Oral Presentation
Keywords: digital outcrop models Leduc

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Upper Devonian carbonate platform exposures in the Rocky Mountains (Alberta) are world-class. The Alberta Geological Survey initiated a program in 2022 called the Devonian Analogue Investigation. The cornerstone of the project is the use of advanced drone technologies to build high-resolution 3D digital outcrop models of classic exposures including Cripple Creek, Wapiabi, Grassi Lakes, Burnt Timber and Hummingbird. More remote, poorly known areas have also been modeled.

The project is being driven by the need for high-resolution datasets of Devonian carbonate platforms that may be used as analogues for the construction of 3D geological models in the subsurface – key for development of energy resources (petroleum and emerging areas including brine-hosted minerals and geothermal) that rely on accurate modeling of many aspects including facies belts and high-permeability zones. Similar needs also exist for carbon storage projects. Application of the analogues, especially when integrated with subsurface datasets such as core descriptions and 3D seismic, should aid with reducing uncertainty and speculation in subsurface modelling efforts. Draped over the 3D outcrop models are data layers that include field locality and sample descriptions, photographs of specific features, vuggy porosity trends extracted with a machine-learning approach, and photomicrographs. The integrated datasets, once public, will provide unparalleled datasets for teaching many aspects of carbonate sedimentology and stratigraphy and for independent research by others. Although these products will not replace the value of field excursions, they greatly aid with accessibility and provide for visualization and data integration in ways not previously possible.

The role of recrystallization in shaping the geochemical signature of dolomite: an experimental study

Oral Presentation
Keywords: experimental dolomite, trace elements, stable isotopes, recrystallization

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Carbonate minerals that form in marine settings often incorporate the geochemical composition of seawater during the time that they precipitated. This is mostly true for aragonite and high-Mg calcite, two polymorphs of $CaCO_3$ that form a significant proportion of modern carbonate sediments, with well-constrained partition coefficients and isotopic fractionation factors. However, aragonite and high-Mg calcite are metastable minerals that are highly subject to diagenetic alterations, resulting in ancient carbonate rocks that comprise low-Mg calcite and dolomite. Interpreting the geochemical signature of dolomite can be challenging because it is notoriously difficult to precipitate in the laboratory, and it has never been observed to form in nature under near-surface, ambient conditions. Thus, it is often unclear whether the geochemical signature of dolomite reflects the precursor $CaCO_3$, the diagenetic fluid, or an intermediate composition between these endmembers. It has also been demonstrated that dolomite can undergo later recrystallization, and thus, its geochemical signature may also be reflective of burial diagenetic conditions. Using high-temperature, dolomitization experiments, we evaluate the mechanisms by which Sr and U partition between the $CaCO_3$ reactant, the diagenetic fluid, and the $CaMg(CO_3)_2$ product. First, we compare their partition coefficients during the dolomitization of aragonite ([Sr] = 8771 ppm; [U] = 2865.1 ppb) versus calcite ([Sr] = 251 ppm; [U] = 287.8 ppb). Next, we assess how different reaction conditions (e.g., temperature and fluid composition) determine the structural parameters and geochemical composition of dolomite. We test the hypothesis that dolomite stoichiometry, cation ordering, and unit cell volume exert a first-order control on the amount of Sr and U that can fit within its crystal structure, which in turn dictates the partitioning coefficient. These experimental results provide novel insights into the role of diagenesis in shaping the geological record, with future work that will investigate the isotopic fractionation of Sr and U.

Dolomite recrystallization as characterized by crystal texture and Mg-C-O isotopes: a case study of Lower Ordovician dolomite from Tarim Basin

Oral Presentation
Keywords: dolomitization, dolomite recrystallization, Mg-C-O isotopes

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Widespread replacement dolomite commonly occurs in the geologic record. These dolomites are generally characterized by different crystal sizes and shapes that have at times been interpreted to represent multistage dolomitization; although the variation of dolomite texture could also have resulted from the recrystallization of precursor dolomite. It is important, but challenging, to differentiate these two scenarios to better understand the nature of dolomite and the associated processes of dolomitization. Our study explores this problem by using Mg-C-O isotope systematics to characterize the different crystal morphologies exhibited by Ordovician dolomites from Yong-An Dam, the Tarim Basin, China.

Ordovician dolomites from Yong-An Dam in the Tarim Basin are matrix replacement dolomite with variety of crystal shape and size, which can be interpreted to be the product of recrystallization from initial fine crystalline dolomite with different degree of recrystallization. This interpretation is supported by the observations of overlapping δ^{26}Mg values (from -1.66 to -2.39‰) and δ^{13}C values (from 0.46 to -1.89‰) in spite of different textures and crystal morphologies, suggesting that these dolomites were formed by the same dolomitizing fluid. By contrast, the δ^{18}O data demonstrate a wide range of values, from -3.8‰ to -8.8‰, corresponding to the different textures and crystal size, related to the different degree of recrystallization with increasing burial temperatures. We suggest that the Mg and C isotopes remained unchanged during recrystallization because Mg and C were rock-buffered, so the recrystallized dolomite inherited Mg and C from the precursor dolomite. Based on these results, it appears that Mg isotopes, together with conventional O-C isotopes, can provide a diagenetically robust geochemical tracer for identifying dolomite recrystallization in the geological record.

Warm acidified seawater and dolomite formation

Oral Presentation
Keywords:

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Many factors have been proposed to explain the paucity of dolomite in recent carbonate sedimentary deposits relative to its abundance in ancient carbonate successions. As to this point no consensus has been reached regarding the cause of this anomaly. Since low temperature solid-state diffusion can be discounted as a method for Mg incorporation into calcium carbonate (as it operates on time scales too long to matter), the replacement of $CaCO_3$ by dolomite is one of dissolution followed by precipitation. Therefore, an often overlooked but required factor in the replacement of limestone by dolomite is that of undersaturation regarding the original calcium carbonate mineral during replacement. Supporting this, laboratory studies as well as modern systems observations show that when undersaturation is reached with respect to all common marine $CaCO_3$ phases, dolomite defaults to the kinetically favored carbonate precipitate. In modern marine pore systems, such undersaturation is most frequently the result of lower seawater temperature (non-equatorial or deep-water settings), resulting in marine waters with higher CO_2 content. However, lower temperatures also have the effect of kinetically inhibiting carbonate mineral formation in general, and so dolomite formation in such settings is minor. Undersaturation can also be driven by CO_2 release and H_2S oxidation associated with the microbial breakdown of organic matter. The degree of undersaturation required for dolomite formation (undersaturation with respect to calcite) is highly localized in modern shallow marine pore systems of warm-water settings, resulting in sparse dolomite formation, but was more widespread during times of elevated atmospheric CO_2, and ocean acidification, predisposing some ancient marine pore water systems to more thoroughly dolomitizing. Furthermore, because oxidation of organic matter drives dolomite formation, near-surface organic-rich deposits such as the remains of microbial mat communities, were more predisposed to dolomite replacement in the acidified oceans of the ancient past than contemporaneous deposits that contained less organic matter.

Bioturbation controls patterns of dolomitization in Lower Jurassic carbonates of central Saudi Arabia

Oral Presentation
Keywords: selective dolomitization, bioturbation, Jurassic carbonates

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This study investigates the role of bioturbation in controlling dolomitization patterns in the Lower Jurassic (Toarcian) Marrat Formation carbonates of Central Saudi Arabia. Analyses include field observations, thin-section petrography, XRD, SEM-EDS and QEMSCAN for mineralogic analysis, and $\delta^{18}O$ and $\delta^{13}C$ to determine the diagenetic conditions.

Quantitative results demonstrate a correlation between bioturbation intensity and the distribution of dolomitized zones, which predominantly occurs within burrows.

Intense bioturbation, dominated by Thalassinoides burrows, is associated with localized zones of dolomitized burrow-fills within a calcite-dominated host rock. The $\delta^{18}O$ values range from -4‰ to -0.5‰ for dolomitized burrow-fill, and from -4.9‰ to -3.3‰ for the host rock calcitic matrix. The $\delta^{13}C$ values range from 1.3‰ to 2.4‰ for dolomitized burrow-fills, and from 1.5‰ to 1.9‰ for the host rock calcitic matrix. The range of values and petrographic properties suggest that dolomite had a less negative $\delta^{18}O$ precursor overprinted by a more negative $\delta^{18}O$ dolomite.

The study suggests that bioturbation played a crucial role in localizing dolomitization. There are two reasonable hypotheses: (1) bioturbation-induced sediment reworking and burrow structures acted as preferential pathways for fluid flow, facilitating the transport of dolomitizing, evaporated, fluids and leading to localized zones of intense dolomitization; or (2) organic matter in burrows bioturbation influenced the biogeochemical conditions within the sediment, promoting dolomite precipitation. Considering that the $\delta^{13}C$ values of the dolomite do not show a significant deviation from open marine values, the preferential fluid pathways hypothesis (1) is most likely, although hypothesis (2) is not disproven.

These findings highlight the significant impact of bioturbation on the distribution and character of dolomitized zones in the Lower Jurassic carbonates of Central Saudi Arabia. Understanding this interplay between bioturbation and dolomite distribution is crucial for improving reservoir characterization and hydrocarbon exploration efforts in regions with similar bioturbated carbonate successions.

500-year wet/dry cycles and extreme hydroclimate events between early-1100s and mid-1200s recorded in Deep Springs Lake, California

Oral Presentation
Keywords: Medieval Climate Anomaly, Carbonate Dryness Index, magnesite, dolomite, calcite, Deep Springs Lake

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Southwestern North America witnessed extreme hydroclimate events based on tree rings and submerged stumps during the Medieval Climate Anomaly and sequential periods. Aiming to explore carbonate minerals as an independent indicator, we collected and examined sediments with mineralogical approaches from Deep Springs Lake (DSL), California, a spring-fed hypersaline playa with continuous deposition. Previous studies reported megadroughts in southwestern North America during the Medieval Climate Anomaly and subsequent periods. However, local records challenge traditional indices based on tree rings and submerged stumps. We explored the assemblage of carbonate minerals as a hydroclimate indicator using sediment samples from a hypersaline playa—Deep Springs Lake (DSL), California. Mineralogical analyses reveal ~500-year wet/dry cycles driven by solar activities and El Niño-Southern Oscillation (ENSO) activities based on variations of carbonate minerals of dolomite, magnesite, calcite and aragonite. There is a primary magnesite-rich layer (~70% Ca-bearing magnesite, ~30% dolomite) deposited 1,000 years ago, and a layer dominated by aragonite and calcite immediately above the magnesite-rich layer. By weighing carbonate minerals based on Mg:Ca ratios required to precipitate, a new Carbonate Dryness Index (CDI) is established. The CDI curve highlights an unparalleled drought in the past millennium during 1090–1150 AD followed by an extreme pluvial period, correlating with nearby local but not regional tree-ring records. The observed ~500-year wet/dry cycles recorded in DSL sediments indicate that the earth may enter global cooling stage (like little ice age) after ~200 years.

Energy transition opportunities in an old oil field—Judy Creek Beaverhill Lake Unit, Alberta, Canada

Poster Presentation
Keywords: CCUS, Devonian reefs, enhanced recovery

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Devonian reefs in the Western Canada Sedimentary Basin have been a source for oil and gas production from world class pools since the early 1950s. Most are currently at the end of their secondary or tertiary recovery phases. Since climate change and CO_2 are a growing concern these large reefs are being re-visited for their CCUS (Carbon Capture, Utilization and Storage) and CCS (Carbon Capture and Storage) potential.

This talk will focus on the Judy Creek Beaverhill Lake Unit and Conifer's plans to implement a CO_2 enhanced oil flood (quaternary) and eventually convert it to a CO_2 storage project. The Judy Creek Beaverhill Lake Unit was discovered in 1959 and has been on production since 1960. Historical original oil in place (OOIP) values range from 750 to 1100 million barrels of oil (MMBO) and current oil recovery is 377 MMBO (34–50% recovery factor). This field produced under primary recovery until 1962 when a peripheral waterflood was implemented. It was changed to a pattern waterflood in the early 1970s, followed by water alternating gas (WAG) hydrocarbon miscible flood from 1985–2016. Since 2017, Judy Creek has reverted back to a pattern waterflood. A successful 2007 CO_2-EOR pilot demonstrated the technical and economical viability of a quaternary CO_2-EOR flood.

The Judy Creek Beaverhill Lake Unit is a limestone reef build-up of the Upper Devonian Swan Hills Formation. The Swan Hills Formation has three key regional sequence boundaries, P4, R0.5, and R4, with evidence of subaerial exposure. Each of these boundaries marks a change in the style of deposition within the build-up which has influenced historical production and will influence future recovery.

Age and temperature of authigenic carbonates associated with lithium-bearing illite claystones at Thacker Pass, Nevada, USA

Poster Presentation
Keywords: carbonate U/Pb, fluorite U/Pb, Δ_{47}, lithium

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As the demand for lithium (Li) rises due to the green energy transition, new sources beyond traditional pegmatite and brine deposits are needed. One promising project is the McDermitt caldera of Southeast Oregon and Northern Nevada, which contains the world's largest known Li deposit, Thacker Pass, in the southern part of the caldera. This project is currently under construction, though the processes that led to the formation of this world-class Li-rich smectite-illite claystone deposit are not fully understood. This study analyzed secondary minerals with displacive fabrics within the Li rich claystones, calcite and fluorite, using laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) for uranium–lead (U-Pb) dating. The calcite nodules in the smectite/illite clays, which formed at 16.37 ± 0.29 Ma, are interpreted to have formed during caldera resurgence. The carbonates were further analyzed for carbon, oxygen, and clumped isotopes to reconstruct the conditions of mineralization. Based on the carbonates' Δ47, their formation temperature ranged from 129 ± 15°C to 155 ± 30°C. The $\delta^{18}O_w$ values from $\delta^{18}O$ suggest a mixture of meteoric waters and likely magmatic fluids. While fluorite replaces calcite in the highest-grade Li-illite claystones, the

fluorite ages are indistinguishable from calcite, and temperature controls on calcite and fluorite formation may control the progression from carbonates to fluorite. The presence of calcite and fluorite associated with the Li-bearing lens supports the idea that the Li-illite alteration occurred in a hydrothermal system during caldera resurgence, rather than during burial diagenesis. This hydrothermal alteration more than doubled the Li endowment in the deposit.

Maximizing oil recovery and carbon storage at Redwater Leduc: a blueprint for sustainable energy development

Poster Presentation
Keywords: EOR, CCUS, western Canada, carbonate

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The Redwater Leduc field, discovered in 1948, is Canada's third-largest oil pool, having produced over 850 million barrels of oil. With a recovery factor of 69%, its exceptional reservoir quality is underscored by an active water drive. Recent advancements, including a 2023 volumetric reassessment and the development of a 3D geomodel, have assessed the field's potential for enhanced oil recovery (EOR) and carbon capture, utilization, and storage (CCUS). The field is characterized by the Upper Leduc Formation, which contains oil trapped by shale seals. Facies analysis reveals reefal structures with stromatoporoids as the primary reef framework.

Conifer Energy's comprehensive study, including seismic reprocessing, log analysis, and geomodelling, updated the 1967 assessment of oil in place from 1.28 billion barrels (BBO) to 1.34 BBO. A 3D geomodel of the oil leg was divided into eight subunits and populated with key reservoir properties, revealing a CO_2 storage capacity of 80 million tonnes in the oil leg and an additional 1,000 million tonnes in the underlying aquifer. The proximity to CO_2 sources from the Alberta Industrial Heartland and stable reservoir pressures make Redwater ideal for CO_2 sequestration.

The 2008 CO_2 EOR pilot by ARC Resources demonstrated the potential for significant oil recovery, achieving a 27% incremental recovery factor. These results, along with insights on CO_2 migration patterns, have informed plans for a commercial-scale EOR-CCUS project. Conifer Energy's planned initiative aims to recover 200 million barrels of oil and sequester substantial CO_2 volumes over 17 years. This project integrates hydrocarbon recovery with climate change mitigation, showcasing the potential of combining EOR with CCUS as a model for sustainable energy development and emission reduction in legacy oil fields.

Genesis of dolomite of the Middle Permian Maokou Formation in central Sichuan: based on petrological, geochemical and chronological evidence

Poster Presentation
Keywords: genesis, dolomite, Middle Permian, central Sichuan Basin

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The Maokou Formation of Middle Permian in Sichuan Basin is an important target for natural gas exploration. In recent years, significant exploration breakthroughs have been made in the dolomite of the 2nd member of Maokou Formation in central Sichuan Basin, indicating promising exploration prospects in this field. However, the genesis of dolomite is still unclear, which restricts the accurate prediction of dolomite distribution. This study is based on detailed core descriptions, samples were selected for tests of the degree of dolomite cation ordering, $\delta^{13}C$, $\delta^{18}O$, $^{87}Sr/^{86}Sr$, REEs and LA-ICP-MS U-Pb dating. It is clarified that: (1) The dolomite is mainly developed in the middle-upper part of the 2nd member of Maokou Formation with a thickness of 1-25m, and it has the characteristics of karst zonation vertically. (2) Low degree of cation ordering value (avg. 0.59), and values of $\delta^{13}C$ (avg. 3.87‰), $\delta^{18}O$ (avg. −7.15‰) and $^{87}Sr/^{86}Sr$ (avg. 0.707474) having similar characteristics to the Middle Permian seawater reveal that the dolomitization fluid is seawater; The REEs normalized distribution patterns have similar characteristics to limestone, and the U-Pb age (261.0~262.0 Ma) corresponds to the Capitanian stage of the Permian Guadalupian Series reveal that the dolomitization occurred Dolomitization occurred relatively early. (3) The shoal distributed in the relatively high part of the paleo-geomorphology was susceptible to syngenetic karstification, and a large fracture-cavern system developed in the phreatic zone, which is filled with bioclastic particles, marl and Mg^{2+} rich seawater, and dolomitization occurred during the shallow burial process. Based on new understanding of dolomite genesis, it is clear that the high part of paleo-geomorphology is the favorable area of dolomite in the 2nd member of Maokou Formation, which provides a basis for the prediction of dolomite distribution in the study area and effectively guides the exploration deployment.