



The Society for Organic Petrology

# NEWSLETTER

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The 40th Annual TSOP Meeting, September 14-22 2024, ULAANBAATAR, MONGOLIA



*Aglag meditation center, located approximately 100km from the Ulaanbaatar*

*Photo by [visitulaanbaatar.net](http://visitulaanbaatar.net)*

## TOP NEWS

- Agenda for the 2024 TSOP meeting in Mongolia
- Change of application deadlines for Ward, Travel, and Spackman Awards
- Call for nomination for John Castaño Honorary Membership Award
- TSOP-EAOG Joint Virtual Seminars
- Obituary for Neely Bostick
- Student members contributions



# TSOP PRESIDENT'S LETTER

Dear TSOP Members,

I trust this note finds each of you well and in great spirits. It's my pleasure to update you on the recent and upcoming events within our society.

Last month, we celebrated a significant milestone with the successful hosting of our inaugural TSOP-EAOG (European Association of Organic Geochemists) joint seminar. The inaugural seminar was enlightening as it offered fresh perspectives and valuable insights within organic geochemistry. I would like to express my heartfelt gratitude to Dr. Joe Curiale for his role as the liaison between the two organizations and his ongoing efforts in fostering this collaboration. I am also pleased to inform you that the next seminar will feature an esteemed colleague, Dr. Paul Hackley from USGS, as our presenter. Keep an eye out for more details on this upcoming event.

Furthermore, it gives me great joy to announce that our annual conference website is now live and ready for your visits and registration. Thanks to our organizing committee for their hard work and dedication!

In the months to come, we will have the privilege of hosting an online seminar with Prof. Joan Esterle, a previous recipient of the John Castano Honorary Membership Award. This event promises to be an exceptional opportunity to learn from one of the leading figures in our field and to celebrate the contributions of our distinguished members.

This time also marks the award selection process by the TSOP award committees. I encourage you all to participate actively in the nomination process. Your recommendations are crucial for acknowledging and celebrating the outstanding contributions of our peers.

As we move forward, I eagerly anticipate your participation in our initiatives and am excited about the growth of our society.

Best wishes,  
Lei Zhao, TSOP President 2023-2025



Dr. Lei Zhao  
TSOP President





Photograph of Main square and parliament house. TSOP 2024 venue is within a few minutes walking distance from here (venue to be officially announced end of March 2024). Photograph courtesy of Mongolian Tourism.

[Meeting website](#)

## Decoding the shift: Organics and Critical Minerals in Future Energy

**ABSTRACTS DUE: 1 July 2024**

It has been four decades since the first official TSOP meeting at Tyson's Corner, Virginia (USA) in 1984. Although the aspiration was always for TSOP to be an internationally recognized professional organization, I think few of us could have imagined the many places in the world we'd end up having our annual meetings. Certainly, not one 24 year old geologist (that's me in case you are wondering).

Thus, it is with great pleasure that we extend an invitation to all the membership to join the 40th Annual Meeting of The Society for Organic Petrology to be held in Ulaanbaatar, Mongolia from **September 14 - 22, 2024**. Not only is Mongolia rich in organic-bearing sediments and a geological setting that can only be described as spectacular, it also sits in a very important geopolitical place in the world. It goes without saying that it once was the center of the largest empire in the history of the world. Our venue (to be announced in two by the end of March on the website) is very near the main square and Mongolian parliament house shown in the above photograph.

So, get your abstracts ready, submit them before **the 1st of July**. We expect an excellent turnout so book your place now. Just go to the guidelines for abstract submission here: <https://www.tsop-2024.com/submission.html>



The schedule is packed with something for everyone (see table of events). We have two very exciting and dare I say topical, workshops (see below for extended descriptions). We have a pre-conference cultural field trip arranged on the 14th of September. The field trip will be various sites around Ulaanbaatar including the Chinggis Khan Statue (truly big and truly spectacular!), Turtle Rock, and wee bit of Horse back riding (you can't get more into the culture in Mongolia than being on a horse!). See below for more on the post-conference field trip.

### Schedule of the 2024 TSOP Annual Meeting, Ulaanbaatar, Mongolia

Date/Time	Sat, 14 September 2024	Sun, 15 September	Mon, 16 September	Tue, 17 September	Wed, 18 - Sun, 22 September
Morning	Cultural Field Trip	*Registration  *Workshop 1: Shale Reservoirs, Prof Marc Bustin, Dr Amanda Bustin, Dr Amanda Bustin  *Workshop 2: Critical Minerals, Prof Shifeng Dai	Technical Sessions	Technical Sessions	POST-CONFERENCE FIELD TRIP
Mid-Day		LUNCH	LUNCH	TSOP Buisness Lunch	
Afternoon		*Workshop 1: Shale Reservoirs, Prof Marc Bustin, Dr Amanda Bustin, Dr Amanda Bustin  *Workshop 2: Critical Minerals, Prof Shifeng Dai	Technical Sessions	Technical Sessions  Closing Remarks and Awards	
Evening	*Registration	*Registration *Ice Breaker  *Council Meeting	*Student Drinks Function  *TSOP Conference Dinner	*Pre-field trip briefing with participants  *Council Meeting (if needed)	

## Exciting Workshops!

Let's talk a little about the preconference workshops. Engage in two thought-provoking workshops led by distinguished experts in the field. Prof. Marc Bustin and Dr. Amanda Bustin from the University of British Columbia, Canada as well as Mr John Hattner and Dr Jim Davidson from NSAI who will unravel the complexities of shale, providing invaluable insights. Dive deeper into the realm of critical minerals in coal with Prof. Shifeng Dai from China University of Mining and Technology in Beijing, China. This is your chance to learn from the luminaries! Visit our website for more details (<https://www.tsop-2024.com/workshop.html>) and see below for little bit more on our speakers.



## WORKSHOP 1

# Shales as unconventional gas and oil reservoirs: geology and engineering

### Instructors



Marc Bustin  
Ph.D., P. Geol., FRSC

**R. Marc Bustin** is a petroleum and coal geology professor in the Department of Earth and Ocean Sciences at the University of British Columbia and president of RMB Earth Science Consultants and Renewable Geo Resources Ltd.



Amanda M.M. Bustin  
Ph.D., P.Eng.

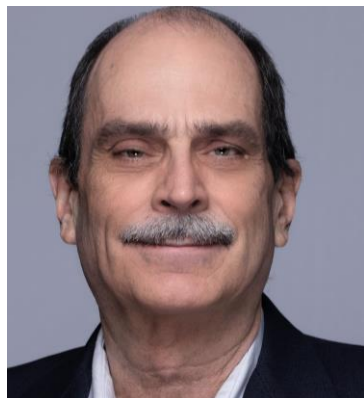
**Dr. Amanda Bustin** is a Research Associate at the University of British Columbia, the President of Renewable Geo Resources Ltd, and the President of Bustin Consulting.



John Hattner  
M.B.A., M.S. Geology

**John Hattner** is a Senior Vice President at Netherland Sewell and Associates Inc. and serves on the Executive Committee for Geology and Geophysics at their Dallas office.





Jim Davidson  
PhD., Petroleum Engineering

**Jim Davidson** is a Vice President with Netherland Sewell and Associates Inc. and a Senior Technical Advisor. He has over 44 years of experience in the oil and gas industry

## WORKSHOP 2

### Understanding Critical Minerals in Coal



Prof. Shifeng Dai  
PhD., Coal Geology, CUMTB

**Shifeng Dai** is a Professor at China University of Mining and Technology Beijing. He is one of the top researchers of inorganic material in coal and an expert in critical minerals and elements.

## CHANGE OF THE APPLICATION SUBMISSION DEADLINES

As travel arrangements, including potential visa application, are required to attend the TSOP annual meeting, the TSOP council has decided to change the submission deadlines for the **COLIN WARD EMERGING STUDENT RESEARCHER AWARD**, **STUDENT TRAVEL AWARD**, to **April 30**. The submission deadline for **Spackman Award** is **May 31**. Please note the change, as the selection of awardees will start earlier than in previous years. Please visit our website for more information.

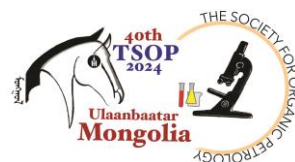
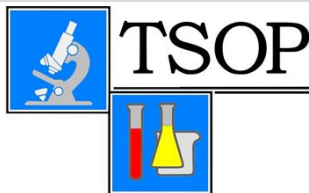
[Ward Award](#)

[Travel Award](#)

[Spackman Award](#)



# Call for Nominations: THE JOHN CASTAÑO HONORARY MEMBERSHIP AWARD



**Submission deadline: May 31, 2024**

TSOP members are invited to nominate the scientist of your choice for the 2024 John Castaño Honorary Membership Award, The Society for Organic Petrology's highest honor. The award acknowledges distinction in a scientific discipline of significance to the Society, in recognition of contributions in research, service to TSOP, or education. The John Castaño Honorary Membership Award conveys life membership in the Society. It is named in honor of John Castaño, one of our most active Houston-based founding members. John served as inaugural Vice-President, and later, as President of TSOP. He was an organizer of three TSOP meetings in the Houston area, and was made an Honorary Member in 1995.

If you would like to nominate a candidate for the 2024 John Castaño Honorary Membership Award, please submit a letter of recommendation and a brief vita of the nominee to [Magdalena Misz-Kennan](mailto:Magdalena.Misz-Kennan@us.edu.pl) at [magdalenamisz@us.edu.pl](mailto:magdalenamisz@us.edu.pl) Chair of the Committee by **May 31, 2024**. It is strongly suggested that supporting letters of recommendation from colleagues and other scientists accompany the nomination package. Emphasis should be placed on the significance of the nominee's research and contributions.



*Nominations will be reviewed by the Castaño Award Committee and results will be announced at the Annual Meeting in September 2024. The selection process is confidential and nominees do not have to be former or current TSOP members.*

**John R. Castaño**

June 10, 1926 - April 20, 1997



# Join Our Mentorship Program

## TSOP Mentorship Program

The Society for Organic Petrology (TSOP) mentorship program is dedicated to helping organic petrologists in successfully managing different challenges, particularly in the earlier stages of their careers, by facilitating the transition of knowledge and experience across generations and providing support and advice where appropriate.

The TSOP mentorship program enables students, early-career researchers, or any organic petrologist to connect with seasoned worldwide experts, educators, and scientists in the field and vice versa. It empowers organic petrologists in training or those at the start of their scientific/academic/industrial careers, i.e., the mentees, to determine or strengthen their focus and develop to their full potential. Simultaneously, it allows mentors to reflect upon and strengthen their mentoring skills, as well as make a valuable contribution to the discipline knowledge base and advancing the science in general.

## Are you searching for mentorship in your career journey?

As a mentee in this program, you have the chance to interact with an experienced professional in the field of organic petrology and ask for advice on specific projects or professional and personal development.

Areas of mentoring include, but are not limited to skills development, career advice, developing research interests, advice on designing a successful research project, publishing research, and advice on work-life balance (to promote success and prevent burnout).

The successfully matched mentor-mentee pairs are contacted and an agreement between the mentor and mentee on participation officially marks the beginning of the one-year program duration.

## Would you like to be a mentor?

As a mentor, you will help to guide and strengthen the next generation of organic petrologists, thus helping to ensure the development and growth of this scientific field.

## Application submission

**Application is possible throughout the entire year by e-mail to Carolina Fonseca, TSOP Councilor (cmfonseca13@gmail.com).**

**Mentors** should provide a short bio and a sentence explaining the type of mentorship they are willing to offer. Mentors from academia, government research and industry are accepted. Mentors do not need to be TSOP members but should be active in their fields of research.

**Mentees** need to provide a short paragraph expressing their expectations from the program, what type of mentorship they prefer, as well as areas of interest.

For more information please visit [www.tsop.org](http://www.tsop.org)



## Introducing a new Series: TSOP-EAOG Joint Virtual Seminars

Dear Society Members,

In February, The Society of Organic Petrology and the European Association of Organic Geochemists (EAOG at <https://eaog.org/>) launched a new quarterly virtual seminar series. This new series is one of the ways we are working to expand scientific interaction and cross-society involvement among TSOP and EAOG members. Our first presentation was given on the 15th of February by Janina Groninga at MARUM – Center for Marine Environmental Sciences (University of Bremen), and it was a great success. Our President, Lei Zhao, gave a brief introductory overview of TSOP, and over 35 people logged into the TEAMS meeting, including many TSOP members. Janina gave an excellent talk, followed by questions from the audience. Future TSOP-EAOG virtual seminars will be presented every three months through 2024 and beyond, each announced a few weeks in advance via social media and direct membership e-mail.

The EAOG-TSOP seminar series is one of several ways that the TSOP Liaison Committee has established to expand TSOP's connections with other professional societies. This outreach has several objectives, and primarily seeks to expand the scientific horizons of our membership into the many areas touched by organic petrology. In addition, members of TSOP and the liaison societies will have the opportunity to meet and potentially collaborate with each other. In the case of TSOP and EAOG, this could involve expanded use of organic geochemical techniques in organic petrology projects and, likewise, the use of organic petrology in geochemical studies. I often refer to this as “the importance of petrologists actually using geochemical analyses together with a microscope – and of geochemists actually looking at the organic matter that they analyze geochemically”.

We hope you enjoy the EAOG-TSOP quarterly virtual seminar series. We welcome suggestions on how to improve the series, and recommendations for speakers.

Joe Curiale (joecuriale1@gmail.com)  
Chair, TSOP Liaison Committee  
Liaison for TSOP-EAOG interactions



# European Association of Organic Geochemists

*An International organization dedicated to promotion and use of Organic Geochemistry in earth sciences*



# Call for Participation in the ICCP Accreditation Programs

The International Committee for Coal and Organic Petrology (ICCP) is pleased to invite you to participate in the 2024-2025 Accreditation round. The ICCP provides three Accreditation Programs:

- **[Single Coal Accreditation Program \(SCAP\)](#)** for both maceral group and vitrinite random reflectance analyses. In this program, the ability of an analyst to identify and quantify the maceral groups and to measure the vitrinite reflectance of coal samples according to ISO standards is tested.

**Organizer: Kimon Christanis ([christan@upatras.gr](mailto:christan@upatras.gr))**

- **[Dispersed Organic Matter Vitrinite Reflectance Accreditation Program \(DOMVR\)](#)**. In this program, the ability of an analyst to identify and measure the reflectance of vitrinite occurring as dispersed vitrinite in rocks such as carbonaceous shales or hydrocarbon source rocks is tested.

**Organizer: João Graciano Mendonça Filho ([graciano@geologia.ufrj.br](mailto:graciano@geologia.ufrj.br))**

- **[Coal Blends Accreditation Program \(CBAP\)](#)**. In this Program, the ability of an analyst to identify the number of coals in a blend and their petrographic characteristics, such as vitrinite reflectance and maceral group composition according to ISO standards, is tested. Organic petrology is the only technique to yield information on the individual component coals within a coal blend.

**Organizer: Małgorzata Wojtaszek-Kalaitzidi ([mwojtaszek@ichpw.pl](mailto:mwojtaszek@ichpw.pl))**

The ICCP has established a procedure to facilitate payments in which a single invoice will be produced. This requires that participants fill in the registration form available in the following link [www.iccop.org/accreditation/accreditation-form](http://www.iccop.org/accreditation/accreditation-form) **before April 30, 2024** in order to expedite the procedures. In addition, the detailed schedule of the Accreditation Programs has been established to provide a reasonable distribution of workload from all activities and to accommodate the timelines for the evaluation process. The expected schedule is summarized in the Table below.

	SCAP	DOMVR	CBAP
Announcement and call for participation	February to April 30, 2024	February to April 30, 2024	February to April 30 2024
Invoicing	till May 31 2024	till May 31 2024	till May 31 2024
Sample distribution	May to June 2024	May to June 2024	December 2024
Reception of results	July to September 2024	July to September 2024	January to March 2025
Evaluation, Certificates and Web	October to December 2024	October to December 2024	April to June 2025
Certificates Validity	01.01.2025 to 31.12.2026	01.01.2025 to 31.12.2026	01.07.2025 to 30.06.2027

If you are interested in joining the programs, please contact the corresponding organizers.

Sandra Rodrigues

Chair of the Accreditation Subcommittee



# Neely Bostick, 1931-2023



Neely Bostick passed away peacefully on September 3, 2023, with his wife Joyce at his side. Neely was 91 years old. Neely was a longstanding member of TSOP and ICCP, serving in several leadership roles for both organizations.

He was awarded the John Castaño Award from TSOP in 2006 in recognition of his outstanding contributions to research in organic petrology, including over 65 publications from the late 1960s through the late 1990s. Neely was an early member of TSOP and present at the first annual meeting in Tysons Corner Virginia in 1984.

Neely Bostick at the 1996 ICCP meeting in Heerlen. Photograph courtesy of Alan Davis.

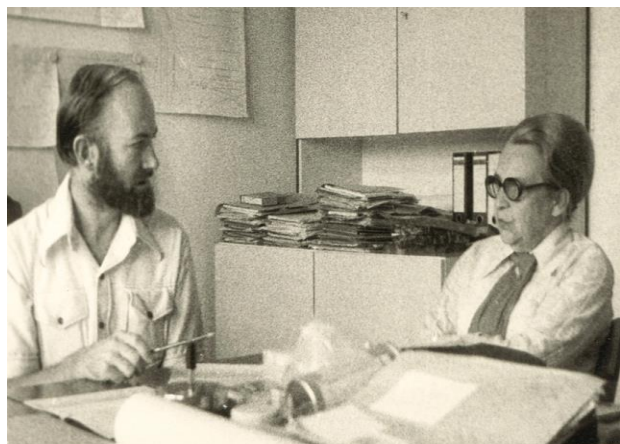
Neely (circled in white) at the 1984 first annual meeting of TSOP in Tysons Corner, Virginia.



Neely served TSOP as Vice-President, then President from 1985 to 1988, later returning to the TSOP Council as the Newsletter editor from 1993 to 1995. He also served on the balloting committee and TSOP's research committee where he facilitated the inclusion of notes in the TSOP News related to 'polishing or embedding techniques, comparisons of kerogen separation techniques, rock color as related to type and amount of kerogen, comparisons of microscope objectives, the effects of solvent extraction and acid treatment on kerogen properties, and the advantages and disadvantages of various immersion media.' These lab notes appeared as letters to the fictional Dr. C.H.O. Anthracos in 1986, reflecting Neely's wry sense of humor. Neely kept at it, writing on 'Measured reflectance suppressed by thin-film interference of crude oil smeared on glass – as on vitrinite in coal or petroliferous rocks' in TSOP News in 2011, fifteen years after he had retired.



Neely was widely regarded as a polyglot, and his translation of Marlies Teichmüller's report 'Fluoreszenz von Liptiniten und Vitriniten in Beziehung zu Inkohlungsgrad und Verkokungsverhalten' (Fluorescence microscopical changes of liptinites and vitrinites during coalification and their relationship to bitumen generation and coking behavior) was well received in the United States.



Neely conferring with Marlies Teichmüller, undated.  
Courtesy of Angeles Borrego.



Neely and Marlies at the 1992 TSOP-ICCP meeting  
at Penn State, PA. Courtesy Alan Davis.

Neely spent a year in Germany in the mid-1970s to establish a new organic petrology laboratory at KFA-Juelich with Chris Cornford. After retiring, he spent time in Kyrgyzstan in the mid-1990s to finish a project on coal resources and mining opportunities in the newly independent country, translating Kasharin's 'Coal geology in Kyrgyzstan during 70 years of Soviet power' from the Russian.

Neely received his PhD from Stanford in 1970 for a study on 'Thermal alteration of clastic organic particles (phytoclasts) as an indicator of contact and burial metamorphism in sedimentary rocks', a work which introduced Neely to dispersed organic matter petrology and which formed the foundation of much of his early research in the 1970s. Neely invented the term 'phytoclast', now widely used and intimately familiar to all organic petrologists and palynologists. While at Stanford, Neely began work on reflectance changes of phytoclasts due to their thermal alteration through contact metamorphism by igneous intrusion, a subject which would follow him throughout his career. Also at Stanford, Neely was a member of the Alpine Club, reflecting his sense of adventure and love of challenges.

After his PhD, his professional career began at the Illinois Geological Survey (1970 to 1975) where he published research on dispersed organic matter petrology, thermal maturation, contact metamorphism of organic matter, and coal resources. While at the Illinois Geological Survey, Neely employed the concept developed during his PhD work of measuring phytoclast reflectance as a rank parameter for use in coal resource assessment.

In 1976, Neely began employment with the U.S. Geological Survey in Lakewood, Colorado, in the Branch of Petroleum Geology, where he continued until retirement in 1996. During his time at USGS Neely performed research in dispersed organic matter petrology, contributing to many studies which supported petroleum resource assessment. This was the most productive phase of Neely's career and also the height of his many contributions to ICCP and TSOP.



In 1976, Neely began employment with the U.S. Geological Survey in Lakewood, Colorado, in the Branch of Petroleum Geology, where he continued until retirement in 1996. During his time at USGS Neely performed research in dispersed organic matter petrology, contributing to many studies which supported petroleum resource assessment. This was the most productive phase of Neely's career and also the height of his many contributions to ICCP and TSOP.

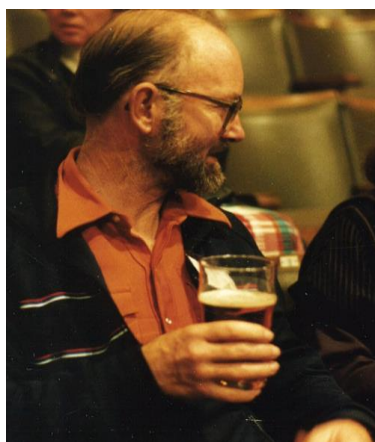
In the ICCP, Neely served as secretary and also chair of the MOD (Matière Organique Dispersée ) activities of the ICCP in its Commission II, coordinating several round robin exercises from the early 1970s to early 1980s, including work to understand contact metamorphism effects to dispersed organic matter. Neely served as an informal liaison between TSOP and ICCP, writing summaries of the ICCP meeting activities for the TSOP Newsletter.



Neely (circled in white) at the 2007 Victoria meeting of TSOP-ICCP.

My own interactions with Neely came long after he had retired from USGS (in 1996). In 2006 and 2007, I traveled with a group from our Reston, Virginia, office out to Denver, Colorado, where Neely had spent his career. When Neely learned I was the 'new' organic petrographer in Reston, he took me under his wing. Thus, as he cleaned out his office, I was the immediate benefactor of various minutia of organic petrology, for example, correspondence on the proper refractive index of immersion oils. His sense of humor was always on full display, almost causing an international conflict when he reviewed the organic petrology review papers of Suarez-Ruiz et al. (published in 2012). And when I encountered Neely at the 2007 meeting of ICCP-TSOP in Victoria, Canada (where he was presented TSOP's Castano Award) he borrowed my cell phone several times to check in with Joyce, running up my bill with international call charges, unbeknownst to both of us at the time.





Neely in Aachen 1988.

Courtesy of Angeles Borrego.

Neely leaves behind his wife of three+ decades, Joyce Bostick of Morrison, Colorado. Neely and Joyce met at the Denver Civic Center through a shared love of folk dancing. Together they cared for a menagerie, having at one time six Icelandic horses, several Siberian huskies, as well as Bouvier des Flandres.

The organic petrology community has lost in Neely Bostick a remarkable scientist whose work has stood the test of time.

*--by Paul Hackley, with support from Alan Davis, Angeles Borrego, Mark Pawlewicz, Jingle Ruppert, Jim Hower, Dave Glick, and from the Castaño laudation by Wolfgang Kalkreuth in TSOP News 25(4).*

## WE NEED YOU INPUTS !

Dear Society Members,

We invite you to contribute to our newsletter! We value your input and would love to hear about your recent achievements, experiences, or any noteworthy events within our TSOP community. Your contributions will help us create a vibrant and engaging newsletter that reflects the diversity and vitality of our society. Additionally, for more information and updates, be sure to visit our [Facebook](#) and [LinkedIn](#) pages and our [website](#), where you can find additional content, connect with fellow members, and stay updated on the latest news and developments within our community. Together, we can make our newsletter and social media platforms a hub of information and connection for our society. We look forward to hearing from you and continuing to build a strong and thriving community together. Please submit items you would like to share to the TSOP Editor **Biao Fu** (please also CC to [fubiao1223@gmail.com](mailto:fubiao1223@gmail.com)).





# STUDENT MEMBERS CONTRIBUTIONS

## Assessment of the Organic Matter Source, Depositional Environment, and Hydrocarbon Generation Potential of Barsingsar Lignite- Shale-Carbonaceous Shale sequence from Western Rajasthan, India

Dinesh Kumar<sup>1</sup>, Ratul Mukherjee<sup>2</sup>, Subhajit Paul<sup>2</sup>, Deepak Kumar Majhi<sup>2</sup>, Tushar Adsul<sup>2</sup>, Atul Kumar Varma<sup>2</sup>

<sup>1</sup>Petroleum Engineering Branch, University Departments, Rajasthan Technical University, Kota, Rajasthan-324010, India

<sup>2</sup>Coal Geology & Organic Petrology Laboratory, Department of Applied Geology, Indian Institute of Technology (Indian School of Mines) Dhanbad, Jharkhand-826004, India

The lignite-shale-carbonaceous shale sequence from western Rajasthan, India, is investigated using the stable carbon isotopes and Rock-Eval Pyrolysis techniques to understand its organic matter (OM) source, depositional environment, and hydrocarbon generation potential. The suit of samples contains two bottom shales overlain by five carbonaceous shales and fourteen lignites at the top. The  $\delta^{13}\text{C}$  values of these samples are more or less narrow, falling from -28.3 ‰ to -24.9 ‰. According to  $\delta^{13}\text{C}$ , the OM was sourced from mixed terrestrial and aquatic C3 plants, especially angiosperms, and to some extent, freshwater algae and freshwater dissolved organic carbon. However, biomarker signals are warranted to pinpoint a particular paleobiota's contribution. The total organic carbon (TOC) content of the lignites is between 39.9 and 58.7 wt%. The hydrogen index (HI) ranging from 247 mg HC/g TOC to 446 mg HC/g TOC suggests the presence of type II (600 mg HC/g TOC to 300 mg HC/g TOC) and type II/III admixed kerogen type (300 mg HC/g TOC to 200 mg HC/g TOC). The average TOC of the carbonaceous shale samples is 3.2 wt%, while it is 5.1 wt% for shales. Similarly, HI of the carbonaceous shales ranges from 240 mg HC/g TOC to 378 mg HC/g TOC; for remaining shales, 352 mg HC/g TOC and 366 mg HC/g TOC. Initial observations from TOC and HI indicate that the suit of samples from the study area possesses an excellent generative potential. In support, the S1 values of lignites averaging 7.6 mg HC/g rock corroborate with interpretation from TOC and HI. However, the average lower S1 of carbonaceous shale (0.8 mg HC/g rock) and shales (0.3 mg HC/g rock) indicate poor contribution/preservation of the reactive organic carbon and hydrogen-rich functionalities owing to differential controls of the depositional environment, which warrants further investigation.

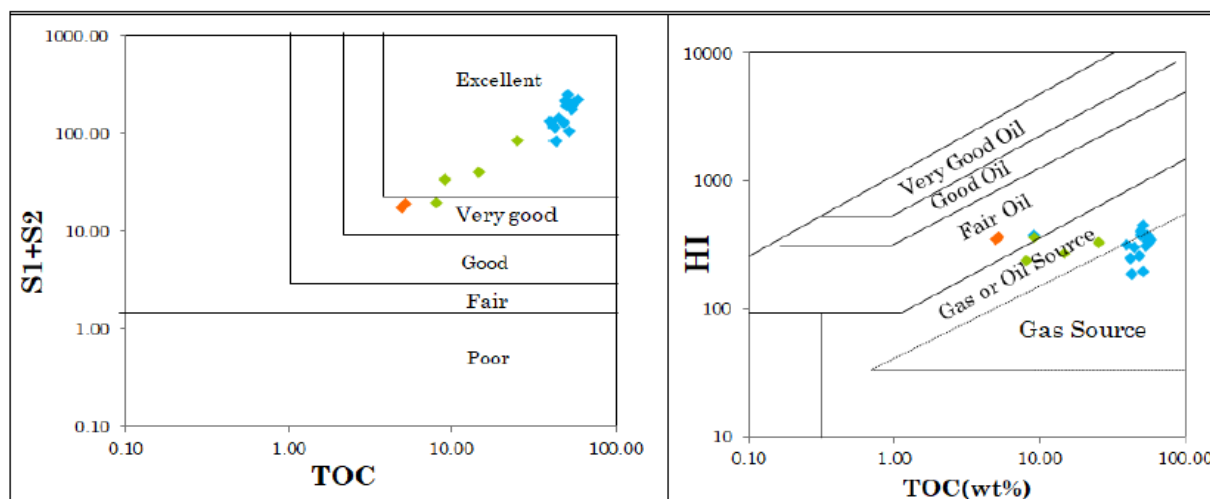


Fig. 1. Rock-Eval parameters



### Source and Paleodeposition Environment of Organic Matter in Paleo-Mesoproterozoic Shales of Vindhyan Basin, India

Susmita Kanu<sup>1</sup>, Dinesh Kumar<sup>2</sup>, Santanu Ghosh<sup>3</sup>, Atul Kumar Varma<sup>1\*</sup>

<sup>1</sup>Coal Geology & Organic Petrology Laboratory, Department of Applied Geology, Indian Institute of Technology (Indian School of Mines) Dhanbad, Jharkhand-826004, India

<sup>2</sup>Petroleum Engineering Branch, University Departments, Rajasthan Technical University, Kota, Rajasthan-324010, India

<sup>3</sup>Department of Geology, Mizoram University, Aizawl-796004, Mizoram, India

This investigation aims to understand the organic matter source and its environment of deposition during the formation of Vindhyan shales of the Paleo-Mesoproterozoic age. The approach includes Stable carbon isotope ( $\delta^{13}\text{C}_{\text{TOC}}$ ) analysis and Rock-Eval Pyrolysis (REP) of seventeen shale samples collected from three different boreholes (NDBH-18, NDBH-26, and NDBH-28) at depths varying from 313 m to 345 m from relative level. The  $\delta^{13}\text{C}_{\text{TOC}}$  values at the NDBH-18 site show a wide variation ranging from  $-31.2\text{‰}$  to  $-25.5\text{‰}$  whereas, at NDBH-26, it ranges from  $-28.2\text{‰}$  to  $-27.0\text{‰}$  while NDBH-28 shows values between  $-26.3\text{‰}$  and  $-24.7\text{‰}$ . Interestingly, samples from the NDBH-18 well show multiple OM sources from particulate organic carbon (POC) freshwater dissolved organic carbon (FDOC) at the bottom section, which then grades upwards to input from freshwater algae and FDOC with increasing influence of the marine algae or tidal derived POC. At the same time, NDBH-26 and NDBH-28 samples show narrow ranges, indicating OM contribution from FDOC and POC. The REP hydrogen index (HI) of these samples ranges from 50 mg HC/g TOC to 500 mg HC/g TOC, indicative of diverse kerogen types such as type II (300 mg HC/g TOC to 600 mg HC/g TOC), type III (50 mg HC/g TOC to 200 mg HC/g TOC) and type II/III admixed kerogen (200 mg HC/g TOC to 300 mg HC/g TOC). The NDBH-18 well shows the mix of all kerogen types (type II, III, and II/III admixed; HI: 50 mg HC/g TOC to 500 mg HC/g TOC), which suggests OM from marine autochthonous (algae) and terrigenous allochthonous (FDOC) sources and corroborates with the  $\delta^{13}\text{C}_{\text{TOC}}$  inference. In contrast, HI values in the samples from NDBH-26 and NDBH-28 range from 90 mg HC/g TOC to 250 mg HC/g TOC, suggesting type III and type II/III admixed kerogen sourced from FDOC and POC.



### **Geochemical paradigms of Paleo-Mesoproterozoic Vindhyan Basin Shales to decipher Kerogen type, Thermal Maturity, and Hydrocarbon Generation Potential**

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This study reports results from the Rock-Eval Pyrolysis (REP) and its various parameters employed to decipher the kerogen type, thermal maturity, and hydrocarbon generation potential of seventeen Paleo-Mesoproterozoic shale samples sourced from Vindhyan Basin, India. A variety of kerogen types, including type II (300 mg HC/g TOC to 600 HC/g TOC), type III (50 mg HC/g TOC to 200 HC/g TOC), and type II/III admixed kerogen (200 mg HC/g TOC to 300 HC/g TOC), are indicated by the samples' overall REP hydrogen index (HI), which ranges from 50 mg HC/g TOC to 500 HC/g TOC. The quality (total organic carbon, TOC) of the organic matter (OM) seems to have been affected due to the age control of the OM source and deposition. The absence of lignocellulosic and woody material in the Paleo-Mesoproterozoic may have resulted in poor contribution/preservation of the TOC, thereby showing average TOC contents of 0.1 wt%. The effects of poor TOC are notable quantitatively in the REP parameters. The concentration of low-molecular-weight, labile, and volatile hydrocarbons (S1 curve) in these samples averages to 0.02 mg HC/ g rock, categorizing them under the poor potential class. The hydrocarbon generation capacity upon maturation (S2 curve) is also deficient (avg. 0.1 mg HC/ g rock), supporting earlier observation. The temperature of maximum hydrocarbon generation under the S2 curve (Tmax) of these samples averages to 437 °C, putting them under the mature zone. The average production index of these samples is 0.16, suggesting an early mature thermal maturation phase. Overall, low TOC values (avg. 0.1 wt%) and extremely low S1 and S2 suggest that the shale samples did not receive enough hydrogen-rich OM and lignocellulosic reactive organic carbon to produce favorable hydrocarbons, possibly due to age constraints. However, the prolonged burial may have caused elevated thermal maturation in these samples.



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