

**100 Years of the divine teacher-student relationship among three generations of Indian geoscientists (1920s-2020s): a remarkable story of knowledge transfer from T. N. Muthuswami Iyer or "TNM" (a Crystallographer and Mineralogist) through A. Parthasarathy (an Engineering Geologist and Quantitative Sedimentologist), to G. Shanmugam (a Process Sedimentologist and \_Petroleum Geologist) and beyond**

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## **Abstract**

The divine teacher-student relationship that covers 100 years of knowledge transfer is the underpinning of this remarkable personal story. Importantly, this narrative is about an Indian genius and a geologic pioneer Professor T. N. Muthuswami Iyer (known as TNM). The first generation (1920s-1960s) TNM began his teaching career as a crystallographer and mineralogist at the University of Madras-Guindy Campus (Chennai) in 1924, and continued at the Presidency College (Madras), Sagar University (Madhya Pradesh), and Annamalai University (Tamil Nadu). One of his early students at Presidency was A. Parthasarathy, who later studied at the Imperial College in London and earned his Ph.D. in Engineering Geology from the London University in 1954. The second generation (1940s-1980s) Prof. Parthasarathy became the Head of Applied Geology section in the Civil Engineering Department at IIT Bombay in 1964. The third generation (1960s-2020s) G. Shanmugam earned his B.Sc. in Geology and Chemistry from Annamalai University with a First Class (1965) and started teaching science in a local high school in his hometown of Sirkazhi, Tamil Nadu. TNM, who was the Head of Geology at Annamalai University in 1965, motivated G. Shanmugam to quit his teaching job and pursue M.Sc. in Applied Geology at IIT Bombay. Shanmugam earned his M.Sc. in Applied Geology at IIT Bombay under the guidance of Prof. Parthasarathy. Education and training at IIT Bombay propelled Shanmugam to receive his second M.S. and Ph.D. degrees in the USA. His Ph.D. research under the guidance of Prof. Kenneth R. Walker at University of Tennessee on Ordovician tectonics and sedimentation in the Southern Appalachians led to securing a research position with Mobil Oil Company in Dallas, Texas in 1978. Because of his global research on multiple domains while at Mobil and as post-retirement consultant since 2000 for oil companies in India and China, Shanmugam has to his credit 380 published works that include three Elsevier books on process sedimentology and petroleum geology (2006, 2012, 2021), with the first two books were translated into Chinese language. He has authored 6 invited Encyclopedia Chapters for Elsevier and McGraw Hill Book Companies and delivered 65 lectures worldwide. Shanmugam won the top award from Springer Journal of Palaeogeography in 2020 for "Excellent Papers" based on Science Citation Index (SCI). Shanmugam's other efforts in knowledge transfer include giving virtual lectures on Zoom, Google Meet, and WebEx platforms to academia (e.g., Royal Holloway, University of London) and conducting 15 onsite workshops on "Deep-water sandstone reservoirs" for oil companies (e.g., Reliance

Industries Ltd. and ONGC in India and RIPED of Petro china in Beijing). The Muthuswami-Parthasarathy-Shanmugam lineage, spanning over 100 years, is unique and phenomenal in knowledge transfer among geoscientists. The acronym "TNM" for my mentor is just perfect for a **T**ransformational, **N**eoteric and a **M**otivating teacher and a noble soul!

**Keywords:** Indian geoscientists, Scientific heritage, Knowledge transfer, T. N. Muthuswami Iyer (TNM), A. Parthasarathy, G. Shanmugam, Teacher-student relationship, Crystallographer, Engineering Geologist, Process Sedimentologist, Petroleum Geologist

## Introduction

The purpose of this document is to track the history behind the divine teacher-student relationship that existed among three generations of geoscientists over a span of 100 years (1920s-2020s) across two countries (India and USA). This remarkable story involves Professor T. N. Muthuswami Iyer, his student Professor A. Parthasarathy at Presidency College, Madras (Chennai), and his student Professor G. Shanmugam at IIT Bombay (Mumbai). This story is told through 52 images. Image numbers are shown on the upper left-hand corner. By design, this is a compendium of anecdotal data on personal, empirical, and historical events. In covering literature, there are 1,615 references.

## T. N. Muthuswami Iyer or "TNM" (1920s-1960s): a Crystallographer and Mineralogist

### TNM's Family Heritage

Professor T. Muthuswami Iyer, popularly known as "TNM", has a rich family heritage (Fig. 1). His father, P V Naganatha Sasthri (1867-1939), also known as Thanjavur Naganatha Sastry, was a distinguished Sanskrit Scholar and a lawyer of great repute. TNM was born in the Madras Presidency under British India, which includes present-day Tamil Nadu, in 1898 (Fig. 1A). TNM was one of 11 children that his parents, Naganatha Sastry and Meenakshi Ammal (1875-1925), had (Fig. 1). Professor T.N Muthuswami Iyer initiated the publication of the Sanskrit treatise 'Sidhantha Kaumudhi' (Published by Motilal Banarsidas). In my editorial view, Prof. Muthuswami Iyer chose to use "TN" rather than "PVN" as his initials in order to emphasize the "Thanjavur" heritage. Thanjavur exemplifies South Indian religion, art, architecture, in particular the Chola temples, which are UNESCO World Heritage Monuments. TNM and his wife Rajalakshmi had two sons and two daughters (Fig. 1A). TNM has an impressive biography (Fig. 1B). TNM and his wife celebrated TNM's 80th birthday with their two sons and their wives in 1978 (Fig. 1C).

TNM family history is available on a Blog called "Sattanathapuram Roots" at

<http://snp-roots.blogspot.com/2008/08/thanjavur-p-v-naganatha-sasthri-1867-to.html?m=1>

### TNM Legacy at Presidency College, Madras (Chennai)

At Presidency, the Department of Geology started in 1916. Following a teaching career at University of Madras (Guindy Campus) from 1924 to 1942 (Fig. 1B), TNM joined the Presidency College in Madras (Chennai). TNM was a classmate of renowned Indian geologist Dr M. S. Krishnan, who was the First Indian Director General of the Geological Survey of India (GSI) (1951-55). In the field, it was a great experience to learn from Prof Muthuswami as he would explain and show intricate geological features like pygmatic folding, unconformity, joints and spheroidal weathering.

A. Parthasarathy V. Swaminathan, and T. M. Mahadevan were his students at Presidency (Fig. 2), TNM taught Crystal Optics, Mineralogy and Petrology. He was a Fellow of the elite Indian Academy of Sciences (F. A. Sc.). TNM's research articles (Muthuswami, 1949, 1951, 1953), published in affiliation with Presidency College, were so influential in Crystallography and Mineralogy (Figs. 3 and 4); they were cited by the mineralogy giants of the day. For example, in 1955, in his seminal chapter "XVIII.—The Geochemistry of the Charnockite Series of Madras, India" (Published online by Cambridge University Press), R. A. Howie cited two articles by Muthuswami (1951 and 1953). Robert Andrew Howie (4 June 1923 – 10 March 2012) was a notable English petrologist. ... W A Deer, R A Howie and J Zussman authored the series 'Rock-Forming Minerals', a widely known mineralogy textbook (1 ed. had 5 vol.). TNM resigned from Presidency in 1953 and went to Sagar University in Madhya Pradesh.

#### TNM Legacy at Sagar University, Madhya Pradesh

TNM joined Sagar University in Madhya Pradesh, India during 1955-57 periods. At Sagar (Fig. 5), TNM worked with the eminent geologic pioneers of India, such as Dr. William Dixon West. Dr. West, who earned his D. Sc. from the Cambridge University (UK), was the Director of Geological Survey of India in 1945. Furthermore, West established the Applied Geology Department at Sagar in 1951. At Sagar University, TNM presumably taught Crystal Optics, Mineralogy, and Petrology.

#### TNM Legacy at Annamalai University, Tamil Nadu

The Department of Geology at Annamalai University in Tamil Nadu started with Prof. N. Rajagopalan in 1953. He was teaching geology for Civil Engineering and B.Sc. students. During the time period 1957-1958, TNM joined the geology department at Annamalai University (Fig. 6). TNM was the first Head of the Geology Department at Annamalai University with faculty strength of 5 members. In 1958, TNM introduced B. Sc (Hons), which was a 3 year degree course. During his tenure, essential equipments for microscopic studies of rock and mineral specimens were procured. The petrographic microscopes were purchased from different countries like Germany & Italy with International Quality with good optical systems. TNM also purchased diagnostic rock specimens from different parts of the world with a characteristic record of the geological processes and time scale. Later, he also initiated the development of crystallographic wooden models for teaching purposes for better understanding about crystals and mineral structure. At Annamalai, V. Panchapakesan was a student of TNM during 1958-62. Panchapakesan would later join IIT Bombay in the faculty of Applied Geology. After TNM's retirement, Prof. N. Rajagopalan, a renowned paleontologist, became the Head of Geology Department at Annamalai University, where he introduced M.Sc. Geology in the Curriculum with a strength of 12 students. In 2021, the Department of Earth Sciences at Annamalai University has 20 faculty members with Prof. T. Ramkumar as the Director of the programme.

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#### **G. Shanmugam's transformation from a local science teacher to a global petroleum geologist**

As mentioned earlier, TNM was the first Head of the Department of Geology at Annamalai University since its founding in 1953 and also during my B.Sc. years (1962–65). TNM was solely responsible for my successful career as a global petroleum geologist. In telling my story, it is imperative to set the background information, which is my family history.

### Shanmugam's Family History

- Shri Andiyappa Mudaliar, my maternal grandfather, was a wealthy diamond merchant in the 1920s and 1930s in Sirkazhi (Fig. 7), Tamil Nadu (then Madras Presidency under British India). He travelled to Johannesburg in South Africa to trade diamonds. He was a philanthropist (Fig. 8) and known for feeding the poor in large numbers frequently in Sirkazhi. He passed away in 1947.
- Before I was born, my father was married to my mother's elder sister (Fig. 8). Because of her terminal illness, my aunt insisted that my father and my unmarried mother get married, so that my mother could raise my aunt's two young children, namely G. Venkatesan (Figs. 8, 10) and G. Rethinasami.
- My parents got married while my aunt was still alive. My aunt prophesied to my parents that their first child would be a boy and that boy should be named "Shanmugam", after her favorite Hindu deity. Thus, I was given the name "Shanmugam". My aunt passed away before I was born in 1944. This is a true story!
- I was born into this affluent family in 1944. When I was a toddler in the mid 1940s, I was often dressed up with all kinds of jewelry (Fig. 9). However, in the early 1950s, my family would suffer a devastating financial loss due to a major robbery at my father's jewelry store in Sirkazhi. In those days, there were no insurance policies to protect wealth. Our family became poor overnight. There was a drastic change in lifestyle, food, etc.
- My parents, although uneducated, thought that the only salvation from their poverty was for me to go to college, earn a degree, and get a steady job/income. So, my education became the central focus of my family.
- Although I understood the family situation, I was unable to excel in studies because I was affected by chronic asthma as a young boy. I could not sleep. I would sit up all night long in order to enable breathing normally. When I was a B.Sc. student in Geology at Annamalai University (Fig. 7), I had to memorize hundreds of mineral names, crystal structure, fossil names, etc. So, instead of sitting idle all night long just to breathe, I started using that time to memorize mineral names, crystal structure, and other topics. This effort was immediately reflected in my exam grades. I passed the B.Sc. final exam in First Class (GPA 4). This incident has taught me the lesson on "Turning obstacles into opportunities". I have been systematically applying this philosophy since 1962 for 60 years now! Results have been phenomenal!!!. In fact, my Keynote Lecture was on this theme at "Protolith 20", a biennial event, at IIT Bombay on December 29, 2020.
- With the advice from TNM, I went to IIT Bombay and then to the USA (Fig. 10). Dr. G. Rajan, Rio Grande Community College, Ohio, and Dr. V. Anantharaman, Professor of Economics at IIT Madras, were helpful in organizing my trip to the USA (Fig. 10). My father came to the Madras Airport to give me send-off to the USA (Fig. 10). That was the last time I saw him because he passed away in 1973 when I was a student in the USA.
- I visited my mother and family in Sirkazhi from the USA as frequently as possible to celebrate family traditions (Fig. 11).
- My mother enjoyed all the modern amenities in the final 10 years of her life (Fig. 12). She passed away the same week in 1997 that memorials for Princess Diana and Mother Teresa were

performed. I would never forget that hectic weekend transitting through the London Gatwick Airport to attend my mother's funeral in Sirkazhi, Tamil Nadu, India.

- Following my grandfather, I also instituted an annual programme to feed nearly 1,000 young students in my hometown of Sirkazhi (Fig. 13). A school bag with gift items (pen, pencil, notebook, sweets, fresh fruits, and Indian rupees) was distributed to each participating student of a “Feast in Memory of the Late G. Savithri” (Shanmugam’s deceased younger sister) (Fig. 13A). This annual feast was organized in Sirkazhi, Tamil Nadu, India during the 1995-2003 period (Fig. 13A). In the year 2000, impressed by my efforts, Ms. Pam Luttrell, Vice President of Exploration, Mobil Oil Company in Dallas, visited the programme in Sirkazhi. The entire programme was brilliantly managed by my close family friend, the late N. Swedaranyam. The programme was terminated in 2003 due to local regulations.
- In the 1990s, I fully restored our family status to its former glory days of the 1930s because of My employment with Mobil Oil Company in Dallas, Texas, USA.

Having told my family history, let me continue my story about TNM.

### Science Teacher

I was born in a town called Sirkazhi, which is located 23 km south of Annamalai University (AU) near Chidambaram in Tamil Nadu, India (Fig. 7). I attended AU as a train student, commuting every day from Sirkazhi to Chidambaram. Although my parents, K. Ganapathy Mudaliar and G. Sambooranam Ammal, were not educated, they were keen on my education. They knew that my education was the only escape out of poverty. Our family consisted of my parents, myself, and four younger sisters, namely Dhanalaxmi, Saraswathi, Chandra, and Savithri (deceased). My parents’ primary concern was dowries associated with my sisters’ forthcoming weddings. This financial background is important to this story.

I earned my B.Sc. degree in geology with a first class (equivalent to “A” grade in the United States). It is worth noting that my degree was signed by Sir C.P. Ramaswami Iyer, then Vice Chancellor of AU. In the summer of 1965, I secured a position as a science teacher at Krishnamoorthy Arunachala Mudaliar High School, located a few kilometers from my home. My parents were ecstatic because for the first time they would have a monthly income from my salary. Normally, my story would have ended as a science teacher, but the story took a drastic turn and continued myself as a petroleum geologist because of TNM.

### Motivations by TNM

During my employment as a science teacher in 1965, I received a postcard from TNM. The card simply read “Come see me.” His postcard was a surprise to me. Anyway, I went to AU and met with TNM in his office. This was my first face-to-face meeting with the Head of the Department. I was rather nervous, not knowing what to expect. TNM greeted me with great affection like a grandfather. He first congratulated me in passing my exams with a First Class. He wanted to know what my plans were for the future. I explained to him that my life is settled in Sirkazhi as a science teacher. He said, “You are one of our top students, you have unlimited potential to become a successful geologist, and you should pursue your graduate studies in Applied Geology at IIT Bombay”. At that time, I did not know anything about IIT Bombay. Given my family’s financial challenges, I knew that TNM’s proposal was impossible. I explained my family situation to TNM. He said in a rather commanding tone, “I cannot let you miss this rare opportunity. Do something to get a loan and go to IIT.” At that point, I realized that I should do something to resolve the financial problem. Although I did not know how to resolve the problem, I told

TNM that I would resolve the problem and would attend IIT. He was pleased with my determination and with my positive response. I did resolve the financial problem by obtaining a long-term loan from a local businessman, Sri. D. Sambandam, who was an elder brother of my childhood friend, Sri. D. Arumugam.

At IIT Bombay, I studied under the supervision of Professor A. Parthasarathy (his DIC and PhD degrees were from the Imperial College and London University, respectively, 1954). My M.Sc. thesis at IIT was on fluvial sedimentology and statistics of textural analysis. I received the Institute Medal for the top-ranking student in Applied Geology (1968). As part of the curriculum, I received my first field training from Oil and Natural Gas Corporation (ONGC) in the Great Rann of Kutch in the Thar Desert under Dr. S.K. Biswas and laboratory training in the Ahmadabad office (Gujarat). IIT Bombay not only prepared me for my sedimentology and petroleum geology career but also led me to pursue graduate studies in the United States.

Throughout my studies at IIT Bombay, I kept TNM informed of my progress. Finally, I informed him about my plans to go to the United States in the Fall of 1970. At that point in time, TNM had retired from AU and settled in Madras. In his response, he wrote me a letter in August 1970. After 50 years, I still have his letter in my possession (Fig. 14). Because of poor resolution of the scanned copy of letter, I have transcribed the letter content below:

“Raja Annamalaipuram-Madras: 10-8-70

My Dear Shanmugam,

Very happy to see your kind letter. I am sure you will have a very successful and bright career in Ohio University. It is very good of you to think of me. Few people have this affection and regard.

I have permanently shifted to Madras. I am staying with my son Naganathan, who is Area Manager-ALITALIA. If you have to book your passage to Ohio he will do everything for you. His office address...

Hope to meet you when you go next to Madras.

Yours sincerely,

T.N. Muthuswami

(Signature)”

Indeed, his son Naganathan (Fig. 1A) did book my passage to America by ALITALIA Airlines. Of course, I did go to his house in Madras and did meet him in person before my departure to the United States. TNM was very proud of my achievements. He would have been even more thrilled to witness my achievements since then, including the arrangements of weddings of all my three sisters. He is in Heaven and smiling down on me, I am sure!

### **A. Parthasarathy (1940s-1980s): an engineering geologist and quantitative sedimentologist**

A. Parthasarathy was born in 1925 in the Madras Presidency, British India. He started teaching at Presidency college in 1945 He joined IIT sometime in 1959 as a faculty member in the Civil Engg. Dept. and retired in 1985, and continued as Prof. Emeritus at IIT Bombay until his passing in 2015 at the age of 95.

#### Evolution of the Department of Earth Science at IIT Bombay

In many respects, TNM was either directly or indirectly responsible for the birth of Earth Sciences at IIT Bombay. For example, his students at Presidency, namely A. Parthasarathy and S. Viswanathan, solely initiated geology programme at IIT Bombay. Furthermore, TNM sent students from Annamalai University to IIT Bombay (e.g., K. Swaminathan and G. Shanmugam). The following is a brief summary of the evolution of Earth Sciences at IIT Bombay.

- Department of Civil Engineering started a geology program for Civil Engineering students in 1959 with Prof. Parthasarathy as a single faculty member. K. S. Balasubramanian joined as a supporting hand as Senior Technical Assistant probably in 1960 or year later.
- In 1963, Prof. S. Viswanathan joined the faculty.
- In 1964, V. Panchapakesan joined as a Senior Technical Assistant. Later, he earned his Ph.D. and became a full Professor.
- Since 1964, Mr. S. P. Vernekar was part of the Applied Geology technical staff. He performed many critical functions that range from maintaining equipments to typing manuscripts. In fact, Mr. Vernekar typed my M.Sc. dissertation in 1968. Another staff was Mr. Mukundan who used to make thin sections.
- In 1964, the first Batch of M.Sc. in Applied Geology degree programme started under the Civil Engineering Department (Fig. 15). K. Swaminathan, prompted by TNM, joined the first Batch. Following is the list of students:

S. No.	Name	Courses Enrolled	Current Organization OR Institute
1	K MUTHURAMAN	M.Sc	NA
2	K SWAMINATHAN	M.Sc	NA
3	N KRISHNAMOORTHY	M.Sc	NA
4	RANGANATHA RAMACHANDRAN	M.Sc	NA
5	S P MUNIAPPAN	M.Sc	NA
6	S MUTHUKRISHNAN	M.Sc	NA
7	SHASHIDAR SHAMRAO OKA	M.Sc	NA
8	SUBRAMANIA SATHYAMOORTHY	M.Sc	NA
9	TALLAPRAGADA PURNACHANDRA KISHORE		

- In 1965, G. Shanmugam, prompted by TNM, joined the second Batch of M.Sc. students in Applied Geology. Following is the full list of students:

S. No.	Name	Courses Enrolled	Current Organization OR Institute
1	ANIL DATTATRAYA MUNGEE	M.Sc	NA
2	D EMILE	M.Sc	NA
3	GANAPATHY SHANMUGAM	M.Sc	NA
4	GOPALAN VISWANATHAN	M.Sc	NA
5	K RAMANATHAN	M.Sc	NA



6	K SHANMUGAM	M.Sc	NA
7	SUJIT KUMAR DUTTA	M.Sc	NA
8	VENKATARAMAN MOHAN		

- 1965: A minor digression. In the above list of classmates, Mr. Mohan reminds me of an encounter with a mega Bollywood star of the 1960s, Miss. Vijayanthimala. Mohan's uncle was her personal manager. For three Applied Geology students from IIT Bombay, he arranged a meeting with her at the Santa Cruz Airport in Bombay in 1965. At that time, she was at the height of her popularity because of the release of the box-office hit movie "Sangam" with Raj Kapoor in 1964. She was gorgeous, kind, cordial, and very curious about Applied Geology at IIT Bombay!
- In 1966, Prof. S. D. Shah joined as a Senior Technical Assistant. Profs. K. C. Sahu, Bhaskar Rao, K. V. Subbarao, B. K. Sahu joined later. The group, still under Civil Engineering Dept. functioned with limited funding.
- In 1968, I completed his M.Sc. dissertation on "Geology of Tankhala Area, Gujarat State" under the supervision of Prof. Parthasarathy. Prof. B. Bhaskara Rao of Applied Geology section guided and supervised me in the remote field study area amid many challenges for lodging and food. Laboratory investigation was aided by Dr. S. Satyanarayana, Dr. G. Mandal, and Dr. A. Sundarajan. Mr. S. P. Vernekar typed my dissertation.
- In 1968, S. Asokan joined the fifth Batch of M.Sc. students in Applied Geology at IIT Bombay.
- In 1969, D. Chandrasekharam joined the sixth Batch of M.Sc. students in Applied Geology at IIT Bombay.
- In 1970, I published an article entitled "ACE Language computer program for moment statistics in size-shape studies of sedimentary particles in the Geol. Bull. of Civil Engineering Dept., Indian Institute of Technology, Bombay, v. 1, pp. 13-17. The CE Geological Bulletin was edited by Prof. Parthasarathy.
- During 1964-82, Prof. Parthasarathy was the Head of Applied Geology Section of the Civil Engineering Department (Fig. 16).
- In 1982, the Applied Geology section of Civil Engineering Department was granted the status of full-fledged independent Department of Earth Sciences.
- During 1982-84 (Fig. 16), Prof. Parthasarathy was the Head of the Department of Earth Sciences. Prof. Parthasarathy was followed by K. C. Sahu, K. V. Subbarao, and B. K. Sahu.
- As mentioned earlier, in 1985 (Fig. 17), Prof. Parthasarathy retired from IIT Bombay, and continued as Professor Emeritus until his passing in 2015.
- Prof. A. Parthasarathy celebrated Prof. S. D. Shah's retirement in 2002 (Fig. 17A),
- In 1989 (Fig. 15), a new building was dedicated to the Department of Earth Sciences.
- During 2000-2003 (Fig. 18), Prof. Chandrasekharam was the Head of the Department of Earth Sciences. Now, retired from IIT Bombay, he is a Visiting Professor at IIT Hyderabad in both Department of Civil Engineering and Department of Climate Change. For his impressive list of Awards and Publications visit: <https://www.geos.iitb.ac.in/dc/>
- On October 1, 2003 (Fig. 19), I delivered a Special Lecture at the Institute Colloquium, entitled "Deep-water processes and turbidite facies models: a paradigm shift". It was organized by Prof. D. Chandrasekharam and was attended by Prof. Parthasarathy from his retirement. In the IIT lecture auditorium, the packed audience gave a Standing Ovation to Prof. Parthasarathy in recognition of his 26 years of service to the Earth Sciences community at IIT Bombay.

- In 2013, Wiley Textbook entitled "Engineering Geology" was published By A. Parthasarathy, V. Panchapakesan, and R. Nagarajan (Fig. 20).
- In 2015, Prof. Parthasarathy's 90<sup>th</sup> Birthday was celebrated with Prof. Chandrasekharam & his wife at the Residence of Prof. Parthasarathy (with his wife) in Mumbai (Fig. 21).
- In 2015, Prof. Parthasarathy passed away at the age of 90.

#### Professor S. Viswanathan

- 1. Professor S. Viswanathan was one of the early students of Professor T. N. Muthuswami Iyer at the Presidency College, Madras (Chennai).
- 2. In 1964, Prof. Viswanathan joined IIT Bombay as a faculty in the Civil Engineering Department.
- 3. In 1964, Prof. Parthasarathy and Prof. Viswanathan introduced the M.Sc. programme In Applied Geology at IIT Bombay under Civil Engineering Department (Fig. 22).
- 4. Professor Viswanathan was the first to earn Ph.D. degree in geology from IIT Bombay (Fig. 22).
- 5. Prof. Viswanathan had interests in several fields of earth sciences, though much of his research work centered on mineralogy, igneous petrology (Deccan Traps) and structural geology.
- 6. In 1973 Prof. Viswanathan was selected for postdoctoral work at the Moscow Geological and prospecting Institute (known as 'EMGREE' –MGPI).
- 7. I was a student of Prof. Parthasarathy, Prof. Viswanathan, and Prof. Panchapakesan at IIT Bombay (1965-68) (Fig. 22). Prof. Viswanathan taught me structural geology.
- 8. D. Chandrasekharam was a student of Prof. Viswanathan at IIT Bombay (1969-72).
- 9. In 2016, Prof. Viswanathan passed away at the age of 89 (Fig. 22).

#### Professor V. Panchapakesan

- 1. Professor V. Panchapakesan was a student of Professor T. N. Muthuswami Iyer at Annamalai University during 1958-62.
- 2. In 1964, V. Panchapakesan joined IIT Bombay as Senior Technical Assistant in the Civil Engineering Department (Fig. 23).
- 3. During 1965-68, he was a teacher of G. Shanmugam at IIT Bombay (Fig. 23).
- 4. In 1976, he earned his Ph.D. in Geology from IIT Bombay
- 5. In 1990, he was appointed as a full Professor in Applied Geology program at IIT Bombay (Fig. 23).
- 6. In 2003, he retired from IIT Bombay and settled in Bengaluru.
- 7. In 2013 (Fig. 23), Prof. Panchapakesan co-authored a book on "Engineering Geology" with Prof. Parthasarathy in 2013, after a successful career at IIT Bombay.
- 8. In 2021, in an email to Shanmugam dated March 3, 2021, he shared the following details about TNM in the field with Panchapakesan while studying Madras Charnockites, "There are several episodes. He used to have me near him during the field trip to Pallavaram for two reasons, one was to teach me and point out significant features of the exposure and the second was to make me carry his flask filled with hot coffee. The first one made me understand geology of the area to some extent and the second one gave some coffee to me which he so lovingly shared. Dr. V. Panchapakesan." The divine teacher-student relationship is the hallmark quality of TNM throughout his extraordinary life as a teacher.
- On December 29, 2020 (Fig. 24), I delivered a virtual lecture on WebEx "Transforming obstacles into opportunities by breaking up of orthodoxies in process sedimentology, physical

oceanography, and petroleum geology." Webinar Protolith 20. IIT Bombay, 9 AM (India Time), Tuesday, December 29, 2020.

<https://www.youtube.com/channel/UCXLo-JjeJ06GBOcaTYBYadQ>

- Since 2020, Prof. Santanu Banerjee has been the Head of the Department of Earth Sciences (Fig. 15). In 2021, both Banerjee and Shanmugam serve on the Editorial Boards of two journals: a) Journal of Palaeogeography (JoP) and b) Journal of the Indian Association of Sedimentologists (JIAS). Both Banerjee and Shanmugam won "Excellent Papers" Awards from JoP in 2020, making the IIT Bombay being the only academic institution in the world to produce two winners in the same year.

## G. Shanmugam (1960s-2020s): a process sedimentologist and petroleum geologist

### Biography

**G. Shanmugam** is a person of Indian origin.

- Born in 1944 in Sirkazhi, Tamil Nadu, India.
- Emigrated to the U.S. in 1970 and became a naturalized U. S. citizen in 1990.
- Married to an American, Jean, since 1976.
- A pragmatic and an iconoclastic deep-water process sedimentologist.
- Primary contributions are aimed at documenting the volumetric importance of sandy mass-transport deposits and bottom-current reworked sands in deep-water petroleum reservoirs worldwide and at dispelling the popular myth that most deep-water sands are turbidites.
- Importantly, debunked the myths of facies models on high-density turbidites (JSR, 1996), tsunamites (JSR, 2006), seismites (JoP, 2016), contourites (Elsevier's Provenance volume, 2016; PED, 2017), and hyperpycnites (JoP, 2018 and AAPG Bulletin, 2018).
- Over 380 published works, including two volumes of Elsevier's Handbook of Petroleum Exploration and Production (2006 and 2012) and their Chinese editions.
- 2021 Elsevier book is entitled "Mass transport, gravity flows, and bottom currents: Downslope and alongslope processes and deposits".

### Professional Preparation

1978: Ph.D., Geology, University of Tennessee, Knoxville, TN., U.S.

1972: M.S., Geology, Ohio University, Athens, OH., U.S.

1968: M.Sc., Applied Geology, Department of Civil Engineering, IIT-Bombay, India

1965: B.Sc., Geology and Chemistry, Annamalai University, Tamil Nadu, South India

Note: Shanmugam served as a research scholar under the Council of Scientific and Industrial Research (CSIR), Government of India, at IIT Bombay during 1968–1970.

Shanmugam, G., 1968, [Geology of Tankhala Area, Gujarat State](#): Bombay, India: Civil Engineering Department, Indian Institute of Technology: Unpublished M.Sc. Dissertation in Applied Geology, 84 p. Adviser: Professor A. Parthasarathy. Field, laboratory, and statistical analysis of fluvial and shallow-marine strata of Cretaceous age.

Shanmugam, G., 1972, [Petrographic Study of Simpson Group \(Ordovician\) Sandstones, Southern Oklahoma](#): Athens, Ohio, Ohio University: Unpublished M.S. Thesis in Geology, 85 p. Adviser: Professor Stanley P. Fisher. Petrographic-diagenetic study of sandstones using subsurface samples provided by Texaco Inc.

Shanmugam, G., 1978, *The stratigraphy, sedimentology and tectonics of the Middle Ordovician Sevier Shale basin in east Tennessee*: Knoxville, TN, University of Tennessee: Unpublished Ph.D. dissertation in Geology, 222 p. Adviser: Professor Kenneth R. Walker. Field and laboratory study of shelf, slope, and basinal deposits with an emphasis on deep-water sedimentation.

#### Teachers and Endowments in India and USA

My teachers in the USA, Prof. Stanley P. Fisher (Fig. 25), Kenneth R. Walker (Fig. 26), and G. Briggs (Fig. 27), played vital roles in my earning M.S. and Ph.D. degrees. In expressing my profound gratitude to these three American Professors as well as to my two Indian Professors (TNM and Parthasarathy), I have established five endowments in both countries to a total amount of \$130,000 (USD).

At Ohio University, Stanley Fisher (Fig. 25) helped me at many levels to get adjusted myself in a new country. He obtained samples from the Ordovician Simpson Sandstone from Texaco to conduct research for my Master's thesis. He was not only my science adviser, but also my financial adviser and social adviser. He held many important positions, such as the Department Head and the Associate Dean of the College of Arts and Sciences.

I would like to emphasize that Professor Ken Walker (Fig. 26) was my perfect teacher during 1974-78. His suggestion to conduct research on the Middle Ordovician Sevier Shale for my Ph.D., although unpopular at the time, was a turning point in my life. The Sevier Shale project allowed me to make a name for myself in sedimentology and tectonics through numerous controversial publications. He taught me how to be a pragmatic and a no-nonsense geologist both in the field and in the laboratory. His philosophy was to follow the data, even if it leads to unpopular conclusions. By watching him and by being with him, I learned how to plan and organize research proposals, how to write research papers, how to set priorities, etc. He held many impressive positions at University of Tennessee. He was the Department Head from 1977 through 1987. From 1996 until his retirement in 2007, he held various research administration positions including Assistant and Associate Vice Chancellor at the Campus Level and Assistant and Associate Vice President at the System Level. His talents were phenomenal. I was blessed to have him as my mentor and friend.

Similarly, I was fortunate to have Garrett Briggs (Fig. 27) as my teacher of clastic sedimentology. He introduced me to the Ouachita Flysch in Arkansas and Oklahoma that would become a major research project with R. J. Moiola at Mobil. Briggs was the one who secured me a job interview with Mobil by convincing Moiola to invite me for an interview. Mobil offered me the unlimited opportunity to travel the world and conduct research on multiple domains. Importantly, Mobil offered me the opportunity to publish profusely.

#### Employment with Mobil Research and Development Corporation, Dallas, Texas

Figure 28 shows three Mobil research laboratories in Texas, United States, where I conducted research during 1978-2000. Top image: Research includes oil generation from coal in the Gippsland Basin, Australia (Shanmugam, 1985a) and porosity enhancement from chert dissolution beneath Neocomian unconformity in the Prudhoe Bay Field, Alaska (Shanmugam and Higglns, 1988). Middle image: Research includes the Ouachita flysch in the USA (Shanmugam and Moiola, 1995) and basin-floor fans in the North Sea (Shanmugam et al., 1995a). It is worth noting that this Mobil Dallas Research Laboratory was designed by a world-renowned architect I. M. Pei, who also designed the Louvre Pyramid in Paris, France. Bottom image: Research includes bottom-current reworked sands by hybrid flows in the Gulf of

Mexico (Shanmugam et al., 1993a), tide-dominated estuarine facies in the Oriente Basin, Ecuador (Shanmugam et al., 2000), and the Annot Sandstone in the Peira Cava area, Maritime Alps, SE France, which served as the type locality for developing the “Bouma Sequence” (Shanmugam, 2002a).

Employment positions held at Mobil:

- 1978-1982      Research Geologist
- 1982-1985      Senior Research Geologist
- 1985-1989      Research Associate
- 1989-1993      Senior Research Associate
- 1993-1996      Assoc. Geological Research Advisor
- 1996-2000      Geological Scientist (retired)

Dr. R. J. Muiola, who was primarily responsible for offering me an interview with Mobil, served as my Mentor at Mobil (Fig. 29). I am grateful to all my colleagues at Mobil (Figs. 30A).

Duties at Mobil

Research on wide range of topics (sedimentology, sequence stratigraphy, tectonics, diagenesis, paleobotany and organic geochemistry) on petroleum exploration and production. Duties also included teaching and core & outcrop description, worldwide. In 2000, Mobil merged with Exxon and became ExxonMobil.

Awards, recognitions, and nomination

- 1968: Received the IIT Medal for the top-ranking student in Applied Geology, Civil Engineering Department, IIT Bombay, India (Fig. 31).
- 1995: Received the Best paper award from NAPE (Nigerian Association of Petroleum Explorationists) for his paper “Deepwater Exploration: Conceptual Models and their Uncertainties.”
- I was interviewed by the SUN TV, Chennai, India (televised on December 30th, 2003) on controversial research papers on turbidite sedimentation and their implications for petroleum reservoirs (Fig. 32). Mr. D. Arumugam's son Balamurali, his friend Ramesh, and my sister Saraswathi attended the interview in the TV Studio (Fig. 32) (See "Dedication" section below).
- Emeritus Member of SEPM (Society for Sedimentary Geology); member since 1970.
- 2018: Recipient of FeTNA 2018 “Tamil American Pioneer” Award for extraordinary professional achievements in academia. FeTNA: Federation of Tamil Sangams of North America. Award Date: June 30, 2018. Frisco, Texas (Fig. 33). <http://tap.fetna.org/category/2018/>.
- 2018: Recipient of the University of Tennessee College of Arts & Sciences 2018 Professional Achievement Award. Award Date: September 21, 2018. Knoxville, Tennessee (Fig. 34). <https://artsci.utk.edu/dialogue/honor-college-alumni/>.
- 2019–21: Nominated for the SEPM 2020 William F. Twenhofel Medal, which is the top award given every year for contributions in sedimentary geology.
- 2020 Springer Journal of Palaeogeography top award for "Excellent papers" based on Science Citation Index (SCI).
- 2021 (May 7): Awarded the "Distinguished Alumni Award" by the Department of Earth and Planetary Sciences of the University of Tennessee, Knoxville, Tennessee (Fig. 34A).

60 Years of knowledge Transfer by G. Shanmugam: 1960s-2020s

I have used multiple means to transfer knowledge to the global geosciences community. One of my early sedimentological contributions was a paper given at the Indian Science Congress with my thesis adviser in 1969:

Parthasarathy, A., and Shanmugam, G., 1969, Sedimentologic characteristics and their significance - studies on Bagh Sandstones in and around Tankhala, Gujarat State: Proc. 56th Session of Indian Science Congress Association, Part 3, Section V, p. 209

The following is a summary of my efforts.

1. Published works: 380 (Please see References, Shanmugam's Research Gate webpage, Shanmugam's BlogSpot site on "Deep-water processes").

Blog: <http://g-shanmugam.blogspot.com/2013/06/g-shanmugams-deep-water-processes-blog.html>

2. Elsevier books (Fig. 35): 5 with two in Chinese translations (Fig. 36) (Please see References).

3. Virtual lectures on Zoom, Google Meet, and WebEx platforms: 6 (2020 and 2021, (Please see References, Shanmugam's Research Gate webpage).

4. YouTube link: 6 (G. Shanmugam channel on YouTube).

5. Research Gate Stats <https://www.researchgate.net/profile/G-Shanmugam-2/stats>

On May 16, 2021

Number of items posted: 187

Reads: 127,747

Citations: 6,746

RG Score: 38.59

[G. Shanmugam's score is higher than 95% of all Research Gate members' scores. On May 2020, the number of members was 1,700,000.](#)

h-Index: 35 (out of maximum 41)

Highest number of reads of a single article "The seismite problem": 7,346

6. I was awarded the top journalism award by the international *Journal of Palaeogeography* on Oct. 28. Shanmugam received this award based on the high citation rates of five papers published in the journal between 2012 and 2018. The award, which carries a prize money of RMB30,000 (Chinese Yuan), is based on the Science Citation Index (SCI) of the following five papers and their SCI ranking:

Shanmugam, G., 2016. [Submarine fans: a critical retrospective](#) (1950\_2015). 5(2): 110–184.

Shanmugam, G., 2015. [The landslide problem](#). 4(2): 109–166.

Shanmugam, G., 2016. [The seismite problem](#). 5(4): 318–362.

Shanmugam, G., 2017. [Global case studies of soft-sediment deformation structures \(SSDs\): definitions, classifications, advances, origins, and problems](#). 6(4): 251–320.

Shanmugam, G., 2018. [The hyperpycnite problem](#). 7(3): 197–238.

Source: <https://www.ohio-forum.com/2020/11/alumni-news-shanmugam-publishes-book-wins-award-for-research-contributions/>

7. My paper 'High-density turbidity currents: are they sandy debris flows?' published in the *Journal of Sedimentary Research* in 1996, has achieved the status of the single most cited paper in sedimentological research published in three world-renowned periodicals - *Journal of Sedimentary Research*, *Sedimentology*, and *Sedimentary Geology* - during the survey period of 1996-2003 (Source: International Association of Sedimentologists Newsletter, August 2003) (Racki, 2003).

#### 8. Organized "Deep-Water Sandstone Workshops"

1995 (October): UK Department of Trade and Industry (DTI), Edinburgh, Scotland

1996 (November): Mobil, Dallas, Texas

1997 (July): UK Department of Trade and Industry (DTI), Edinburgh, Scotland, U.K.

1998 (June): Petrobras, Mobil, and Unocal, Sao Mateus, Brazil, South America

1998 (August): Oil and Natural Gas Corp. (ONGC), Dehra Dun, India.

1998 (November): Petrobras, Mobil, and Unocal, Rio de Janeiro, Brazil, South America

1999 (June): Mobil, Dallas, Texas, U.S.A.

1999 (August): Petrobras, Mobil, and Unocal, Sao Mateus, Brazil, South America

2002: Hardy Exploration and Production (India) Inc. Chennai, India

2002, 2004, and 2009: Oil and Natural Gas Corporation (ONGC), Chennai and Karaikal, India (Fig. 37)

2006, 2007, 2008, 2009, & 2010: Reliance Industries Ltd. Kakinada and Gadimoga, India (Figs. 38, 39, 40)

2006: A T-Shirt was distributed to each participant of the Reliance "Deep-water Rock Expo" Organized by G. Shanmugam in Kakinada, Andhra Pradesh, India (Fig. 40A). Reliance Industries Ltd. (RIL) Managers: Anil Kumar, Rabi Bastia, Bhagaban Das & S. K. Shrivastava.

2009 and 2010: Research Institute of Petroleum Exploration and Development (RIPED) of Petro China, Beijing, China (Fig. 41)

2010: Society of Petroleum Geophysicists (SPG), Hyderabad, India

2014 (May) China University of Petroleum, Qingdao, China (Fig. 42)

2014 (May): Yanchang Oilfield Exploration and Development Research Institute of Yañan Branch Yañan, China

#### 9. Organizer of clastic facies field course (3 weeks) for Saudi Aramco, Dhaharan, Saudi Arabia:

1990 (3-21 November), Saudi Aramco, Saudi Arabia. Field area includes Qassim and vicinity. Modern and ancient deposits were investigated in the field. Seismic profiles, well logs, and cores from petroleum-producing fields were used in class exercises.

#### 10. Organizer of 2nd APG (Association of Petroleum Geologists-India) Short Course in Kajuraho, India

2004 (22-23 September) Pre-Conference Short Course on "Deep-water Processes and Facies Models: Implications for Sandstone Petroleum Reservoirs" at the 2<sup>nd</sup> APG (Association of Petroleum Geologists-India) Conference and Exhibition in Khajuraho, India.

#### 11. Invited speaking engagements and other activities

1980: Lamont-Doherty Geological Observatory of Columbia University - USA

1980: Graduate School of Oceanography, University of Rhode Island - USA

1981: Saskatchewan Geological Society, Regina (1981) - Canada

1982, 1983, 1984, & 1987: University of Texas at Arlington - USA

1982, 1983, 1984, 1985, & 1987: University of Texas at Dallas - USA  
 1984 & 1985: Southern Methodist University, Dallas - USA  
 1983: University of Victoria at Wellington - New Zealand  
 1984: University of Parma - Italy  
 1984: NATO Advanced Study Institute - Conference on "Reading Provenance from Arenites" Calabria - Italy  
 1984: Nigerian Association of Petroleum Explorationists, Annual Conference, Lagos - Nigeria  
 1985: University of Bergen, Bergen - Norway  
 1985: Norwegian Petroleum Society, Stavanger - Norway  
 1985, 1986, & 1990: Dallas Geological Society, Dallas, TX - USA  
 1985: Abilene Christian University, Abilene, TX - USA  
 1985 & 1987: University of Tennessee, Knoxville, TN - USA  
 1986: West Texas Geological Society, Midland, TX - USA  
 1987 & 1990: Fort Worth Geological Society, Fort Worth, TX - USA  
 1987: Society of Exploration Geophysicists, Dallas, TX - USA  
 1987: AAPG Research Conference on "Prediction of Reservoir Quality through Chemical Modeling," Park City, Utah - USA  
 1988: Abilene Geological Society, Abilene - USA  
 1988: COMFAN II, Parma - Italy  
 1989: AAPG Research Symposium on "Application of Chemical Modeling to the Prediction of Reservoir Quality", San Antonio, Texas - USA  
 1989: West Texas Geological Society Symposium "Search for the subtle trap hydrocarbon exploration in mature basins", Midland, Texas -USA  
 1990: Dhahran Geological Society, Dhahran - Saudi Arabia  
 1991: Geological Society of London Symposium: Diagenesis at Unconformities- Implications for Reservoir Quality, London-UK  
 1991: Dallas Geological Information Library, Dallas, TX - USA  
 1992: Arthur Holmes Conference on Deep-water massive sands, Cefalu, Sicily - Italy  
 1993: Norwegian Petroleum Society, Stavanger - Norway  
 1994: Lafayette Geological Society, Lafayette, Louisiana - USA  
 1994: Geological Society of London Symposium: Progress in Sequence Stratigraphy: London - U.K.  
 1995: AAPG International Conference and Exhibition, Nice - France.  
 1995: Azerbaijan Association of Petroleum Geologists 2nd Intl Conference, Baku - Azerbaijan.  
 1995: Nigerian Association of Petroleum Explorationists 13th Annual Conference, Lagos - Nigeria  
 1996: Geological Society of London Conference "Reservoir Modeling of turbidite systems", London - U.K.  
 1996: AAPG International Conference and Exhibition, Caracas - Venezuela.  
 1996: Tulsa Geological Society, Tulsa, Oklahoma - USA  
 1996: Society of Exploration Geophysicists, Denver, Colorado - USA  
 1997: Houston Geological Society, Houston, Texas - USA  
 1997: Bureau of Economic Geology, Austin, Texas - USA  
 1997: SEPM Debate on deepwater processes at the AAPG Convention in Dallas, Texas. Moderator: Ed Clifton; Panelists: Arnold Bouma, Jed Damuth, Don Lowe, Gary Parker, and G. Shanmugam, Texas - USA  
 1997: AAPG International Conference and Exhibition, Vienna - Austria  
 1998: Geoscience 98, Keele - England  
 1999: Petrotech -99, New Delhi - India  
 1999: AAPG, San Antonio, Texas - USA  
 1999: GCSEPM, Houston, Texas - USA  
 2002: Dallas Geological Society International Group, Texas - USA



2002: Association of Petroleum Geologists (APG), Mussoorie - India  
 2002, 2004, & 2009: Oil and Natural Gas Corporation (ONGC), Chennai and Karaikal - India  
 2004: Association of Petroleum Geologists (APG), Kajuraho - India  
 2004, 2006, 2007, 2008, 2009, & 2010: Reliance Industries Limited, Mumbai – India  
 2006: Association of Petroleum Geologists (APG), Goa – India  
 2009: SIPES Houston Continuing Education Seminar, Jan. 12, 2009, Houston, Texas  
 2010: 6<sup>th</sup> China National Petroleum Sequence Stratigraphy Conference: Hangzhou - China,  
**2010: 8<sup>th</sup> International Conference & Exposition on Petroleum Geophysics, “Hyderabad-2010”, SPG - India**  
 2010: AAPG Annual Convention and Exhibition, New Orleans, Louisiana - USA  
 2011: CAPG (Chinese Association of Petroleum Geologists): Beijing - China  
 2014: China University of Petroleum: Qingdao - Eastern China  
 2014: Yanchang Oilfield Research Institute: Yan’an - Central China.  
 2015, 2018: Earth and Planetary Sciences, University of Tennessee, Knoxville, USA  
 2016, 2018: Earth and Environmental Sciences, University of Texas, Arlington, USA  
 2018: 31st Annual Convention: FeTNA: Federation of Tamil Sangams of North America.  
<http://tap.fetna.org/category/2018/>

2018: Dallas Geological Society. International Dinner, November 14, 2018: Lecture topic: "Deep-Water Sand Reservoirs: A Global Satellite Survey of Density Plumes Does Not Support Conventional Turbidite Fan Models"

2020. Transforming obstacles into opportunities by breaking up of orthodoxies in process sedimentology, physical oceanography, and petroleum geology: Webinar 2, Protolith 20. Department of Earth Sciences, IIT Bombay,

2020. The turbidite-contourite-tidalite-hybridite problem: Orthodoxy vs. empirical evidence behind the "Bouma Sequence“ Zoom Journal of Palaeogeography Global Conference on Deep-Water Systems, October 17, 2020, Beijing, China

2021 Facebook Watch. Turning obstacles into opportunities by a Tamil geologist. Special Lecture given at the Dallas MTS (Metroplex Tamil Sangam) 2021 India's Republic Day Celebration on January 26, 2021

## 12. 2016 Lecture tour of India

Please see table below for details on the 2016 India lecture tour

### Institutions:

RIL: Reliance Industries Ltd.  
 ISI: Indian Statistical Institute  
 IITB: Indian Institute of Technology-Bombay  
 IITM: Indian Institute of Technology-Madras  
 Annamalai University, Chidambaram, Tamil Nadu

### Contacts:

Mr. Bhagaban Das, Manager, Reservoir Characterization, RIL  
 Prof. Sarbani Patranabis-Deb, ISI, Geological Studies Unit

Prof. M. Radhakrishna, IITB, Earth Sciences  
Prof. Santanu Banerjee, IITB, Earth Sciences  
Prof. P. Shanmugam, IITM, Ocean Engineering  
Prof. T. Ramkumar, Annamalai University, Earth Sciences

I thank the above Indian colleagues for organizing my lectures. I also thank RIL and ISI for absorbing domestic airline, ground transportation, and lodging expenses.

**Prof. G. Shanmugam's 2016 Lecture Tour Agenda in India**

<u>Location/Intstitution</u>	<u>Date</u>	<u>Time</u>	<u>Topic</u>
Arrival from the US	November 6, Sunday	AM	---
RIL, Mumbai	November 7, Monday	AM	<a href="#">Contourites</a>
RIL, Mumbai	November 7, Monday	PM	<a href="#">SSDS and Earthquakes</a>
RIL, Mumbai	November 8, Tuesday	AM	<a href="#">The landslide problem</a>
IIT-Bombay (Mumbai)	November 8, Tuesday	2.30 PM	<a href="#">SSDS and Earthquakes</a>
IIT-Bombay (Mumbai)	November 8, Tuesday	4.30 PM	<a href="#">Contourites</a>
Mumbai-Kolkata	November 9, Wednesday	Noon	---
ISI, Kolkata	November 10, Thursday	11.30AM	<a href="#">SSDS and Earthquakes</a>
ISI, Kolkata	November 10, Thursday	1.30 PM	<a href="#">The landslide problem</a>
ISI, Kolkata	November 11, Friday	11.30AM	<a href="#">Contourites</a>
Kolkata-Chennai	November 11, Friday	7 PM	---
Annamalai Univ., TN	November 16, Wednesday	3 PM	<a href="#">SSDS and Earthquakes</a>
IIT-Madras (Chennai)	November 24, Thursday	11 AM	<a href="#">SSDS and Earthquakes</a>
Departure from India	November 25, Friday	AM	---

Talk-specific articles:

- Shanmugam, G., 2017. Contourites: Physical oceanography, process sedimentology, and petroleum geology. *Petroleum Exploration and Development (PED)*. Elsevier, 44, Issue 1.
- Shanmugam, G., 2017. The fallacy of interpreting SSDS with different types of breccias as seismites amid the multifarious origins of earthquakes: Implications. *Journal of Palaeogeography*, 6, Issue 1.
- Shanmugam, G., 2015. The landslide problem. *Journal of Palaeogeography*, 4(2), 109-166.

Talk-related articles:

- Shanmugam, G., 2003. Deep-marine tidal bottom currents and their reworked sands in modern and ancient submarine canyons. *Marine and Petroleum Geology* 20, 471-491.
- Shanmugam, G., 2006. The tsunamite problem. *Journal of Sedimentary Research* 76, 718–730.
- Shanmugam, G., 2008a. Deep-water bottom currents and their deposits. In: Rebesco, M., Camerlenghi, A. (Eds.), *Contourites, Developments in Sedimentology*, vol. 60. Elsevier, Amsterdam, pp. 59-81 (Chapter 5).
- Shanmugam, G., 2013. Modern internal waves and internal tides along oceanic pycnoclines: challenges and implications for ancient deep-marine baroclinic sands. *AAPG Bulletin*, 97 (5), 767-811.
- Shanmugam, G. 2016. The seimite problem. *Journal of Palaeogeography*, 5(4), 318-362.
- Shanmugam, G. 2016. The Contourite Problem. In: Mazumder, R. (ed.), *Sediment Provenance*. Elsevier. Chapter 9 (2016, in press, October release).
- Shanmugam, G., Spalding, T.D., Rofheart, D.H., 1993. Process sedimentology and reservoir quality of deep-marine bottom-current reworked sands (sandy contourites): an example from the Gulf of Mexico. *AAPG Bulletin*, 77, 1241-1259.

Download available from G. Shanmugam's [ResearchGate](#) webpage

### 13. 2003-2004: Courses taught at the University of Texas at Arlington

- Spring 2003: Geology 3442: [Sedimentology and Stratigraphy](#)
- Fall 2003: Geology 5344 and 4305: [Clastic Depositional Environments](#)
- Spring 2004: Geology 3442: [Sedimentology and Stratigraphy](#)

In 2000, Prof. John Wickham, Chair of Geosciences Department, appointed me as an Adjunct Professor at UTA. In 2021, Prof. Arne Winguth is the Chair of Earth and Environmental Sciences at UTA.

### 14. 2017-2021 Editorial Board

- Associate Editor-in-Chief of the *Journal of Palaeogeography* (Springer)
- Editorial Board Member of the *Petroleum Exploration and Development* (Elsevier).
- Editorial Board Member of the Journal of Indian Association of Sedimentologists.

### 15. 2021 Alumni Symposium at Ohio University Geological Sciences (OUGS)

In the 2021 OUGS Alumni Symposium, I presented a talk on "[Recent advances in interpreting deep-marine deposits](#)" on Saturday (April 17) at 12.05 PM ET. This talk is based on my 2021 book and on an article in press in the April 2021 issue of the *Journal of Palaeogeography* entitled "[The turbidite-contourite-tidalite-baroclinite-hybridite problem: orthodoxy vs. empirical evidence behind the "Bouma Sequence"](#)". *Jour. Palaeogeography*, v. 10, No. 1. Online <https://doi.org/10.1186/s42501-021-00085-1>

#### **Abstract**

The underpinning problems of deep-water facies still remain unresolved. (1) The Tb, Tc, and Td divisions of the turbidite facies model, with traction structures, are an integral part of the "Bouma Sequence" (Ta, Tb, Tc, Td, Te). However, deposits of thermohaline contour currents, wind-driven bottom currents, deep-marine tidal currents, and baroclinic currents (internal waves and tides) also develop discrete rippled units, mimicking Tc. (2) The application of "cut-out" logic of sequences, which was originally introduced for the "Bouma Sequence", with sharp basal contacts and sandy divisions containing well-developed traction structures, to muddy contourites with gradational basal contacts and an absence of well-developed traction structures is incongruent. (3) The presence of five internal divisions and hiatus in the muddy contourite facies model is in dispute. (4) Intersection of along slope contour currents with down slope sediment-gravity flows, triggering hybrid flows, also develops traction structures. (5) The comparison of genuine hybrid flows with down slope flow transformation of gravity flows is inconsistent with etymology of the term "hybrid". (6) A reexamination of the Annot Sandstone at the Peira Cava type locality in SE France fails to validate either the orthodoxy of five internal divisions of the "Bouma Sequence" or their origin by turbidity currents. For example, the "Ta" division is composed of amalgamated units with inverse grading and floating mudstone clasts, suggesting a mass-transport deposit (MTD). The "Tb" and "Tc" divisions are composed of double mud layers and sigmoidal cross bedding, respectively, which suggest a tidalite origin. (7) Although it was reasonable to introduce a simplistic "Bouma Sequence" in 1962, at a time of limited knowledge on deep-water processes, it is obsolete now in 2021 to apply this model to the rock record amid a wealth of new knowledge. (8) The disconnect between 12 observed, but questionable, modern turbidity currents and over 10,000 interpreted ancient turbidites defies the doctrine of uniformitarianism. This disconnect is attributed to routine application of genetic facies models, without a pragmatic interpretation of empirical data. (9) A suggested solution to these problems is to interpret traction structures in the sedimentary record pragmatically on the basis of empirical field and experimental evidence, without any built-in bias using facies models, such as the "Bouma Sequence". (10) Until reliable criteria are developed to distinguish

traction structures of each type of bottom currents based on uniformitarianism, a general term “BCRS” (i.e., bottom-current reworked sands) is appropriate for deposits of all four kinds of bottom currents.

Outline of my talk

1. History
2. Downslope gravity-driven processes
3. Soil mechanics and slope stability (N. Sea and Antarctica)
4. Fluid mechanics and turbidity currents (Gabon and Equatorial Guinea)
5. The Bouma Sequence (Annot Sandstone, SE France)
6. Global circulation of water masses (Mozambique and Atlantic)
7. Tidal currents in submarine canyons (Nigeria)
8. Internal waves (Andaman Sea and Horizon Guyot, Pacific)
9. Hybrid flows (Gulf of Mexico)
10. Wind-forcing of sediment plumes (Elwha River, Strait of Juan de Fuca)
11. Tsunamis (Lituya Bay, Alaska and Tongatapu Is., SW Pacific)
12. Uniformitarianism
13. Lessons learned
14. Acknowledgements
15. AAPG Bulletin cover photos
16. Q&A.

Selected slides from the talk are included in Appendix A (see p. 164).

Talk is also available on YouTube link:

[https://www.youtube.com/watch?v=v0n3mp\\_XQBY](https://www.youtube.com/watch?v=v0n3mp_XQBY)

### **The T. N. Muthuswami Iyer-T. M. Mahadevan Lineage**

Although this story is focused on the teacher-student relationship related to my career, there are numerous other such stories. For example, the story of T. M. Mahadevan is very impressive. At Presidency College, Mahadevan did his MSc by research guided by Prof. TNM during 1948-1949 and joined Geological Survey of India. Viswanathan was his classmate during his B. Sc. Honors (1944-1947) years at Presidency. T. M. Mahadevan eventually became the Director of Atomic Mineral Directorate (AMD) (Fig.43), now retired from AMD. He and Chandrasekharam co-authored the Viswanathan's Obituary (Fig.22).

### **The T. N. Muthuswami Iyer - A. Parthasarathy - S. Asokan Lineage**

Both Shanmugam and Asokan followed similar paths

1. Both were born in Sirkazhi, Tamil Nadu.
2. Both received their M.Sc, in Applied Geology at IIT Bombay.
3. Both were supervised by Prof. Parthasarathy at IIT Bombay
4. Both received their IIT Medal for top-ranking student in Applied Geology.
5. Both earned their Ph.D., Shanmugam from University of Tennessee (USA), Asokan from Cambridge University (UK)
6. Both have been successful in their professional careers.
7. Shanmugam excelled in publications and in the petroleum industry

(see “60 Years of Knowledge Transfer” section above),

8. Asokan has been a Business Leader and a Geology & Mining professional.

9. 1975 – 1991: Asokan was the Corporate Head and General Manager, GEM Division, of ACC (The Associated Cement Companies Limited), India.

10. 2003: Asokan was a Chief Executive Titanium Project, TATA Steel heritage (Fig. 44).

11. 2003: Asokan received IIT Bombay “Distinguished Alumnus Award”

<https://www.alumni.iitb.ac.in/en/awards/2003/distinguished-alumnus/dr-sundaresan-asokan>

### **The Story of K. Swaminathan-G. Shanmugam-S. Asokan Trio from Sirkazhi who earned M.Sc. in Applied Geology from IIT Bombay**

It is a remarkable story that three students, namely, K. Swaminathan, G. Shanmugam- S. Asokan, from Sirkazhi area would select IIT Bombay to pursue M.Sc. in Applied Geology during different years heritage (Fig. 45). Both Shanmugam and Asokan were born in Sirkazhi town proper, but Swaminathan was born in a nearby (5 km) Kadavasal village, which is located within the Sirkazhi Taluk. He and I have been friends for nearly 60 years.

- We both attended Sabhanayaka Mudaliar Hindu High School (SMHHS) in Sirkazhi. Swaminathan was the top-ranking student in the final year 1960. He was one year senior to me.
- We both attended Annamalai University, as train students, commuting from Sirkazhi to Chidambaram (Fig. 46).
- At IIT Bombay, his M.Sc. dissertation was supervised by Prof. K. S. Balasubramaniam.
- After M.Sc. from IIT Bombay, Swaminathan pursued a very successful business career in Chennai.
- He is the founder and Patriarch of the Swathi Group of Companies in Chennai.
- **SWATHI GROUP OF COMPANIES IS A VIBRANT BUSINESS CONGLOMERATE KNOWN FOR ITS DIVERSE & HIGHLY SUCCESSFUL BUSINESSES.**

SWATHI  
*group*



Visit [swathigroup.com](http://swathigroup.com)

- He lives in a palatial home in the middle of T. Nagar, Chennai (Fig. 47).
- He helped me during 1962-1970 periods in many aspects, which include books, notes, clothes, and financial affidavit to obtain visa for the USA. He did come to the Madras Airport to give me send-off to the USA (Fig. 10).

### **TNM: Transformational, Neoteric and a Motivating teacher & a noble soul**

TNM was the embodiment of Teaching, Novel ideas, Mentoring, Efficiency, and cultivating Ethics & Morality in students with a pioneering zest (Fig. 48). He exemplified these core principles throughout his professional and personal life, be it:

- 1) Teaching Crystallography in classrooms,
- 2) Introducing and Operating E. S. Federov four-axis Universal stage microscope (which came into existence in 1892),
- 3) Calculating Niggli value in Normative Mineralogy,
- 4) Describing Madras Charnockites in Pallavaram, Tamil Nadu,
- 5) Publishing innovative mineralogical studies,
- 6) Documenting basic methods of geologic mapping,
- 7) Developing new curriculum in Geology in the 1940s and 1950s that India critically needed,
- 8) Keeping abreast of advances made in other countries (Russia, Germany, USA) with a view to keep knowledge transfer up-to-date in the Independent India,
- 9) Motivating students like me to aspire for new heights,
- 10) Maintaining an Intellectual honesty & heritage,
- 11) Demonstrating excellence in geosciences by his association with legends of Indian Geosciences, like Dr. W. D. West and Dr. M. S. Krishnan, and finally,
- 12) Raising a wonderful family with two successful sons and two daughters and grandchildren.

Therefore, the acronym "TNM" is just perfect for a **T**ransformational, **N**eoteric and a **M**otivating teacher and a noble soul!

### Concluding Remarks

1. I still remember vividly the day in 1965 when TNM advised me to quit my teaching job and go to IIT Bombay to pursue my M.Sc. in Applied Geology. That seminal moment truly and magnificently transformed my life.
2. The Muthuswami-Parthasarathy-Shanmugam Lineage is unique in the history of Indian geosciences heritage (Fig. 49).
3. I am truly blessed to have multiple teachers originated from the divine and supreme knowledge of TNM at various educational institutions in India and converge upon IIT Bombay at the same time and transfer their knowledge to me is simply phenomenal (Fig. 50). Consequently, the entire geosciences community benefits from TNM!

### Acknowledgements

I thank TNM for giving me this wonderful life of a geoscientist who has described over 11 km of rocks from all over the world. In authoring this tome, I sincerely thank the following esteemed colleagues for providing historical information in compiling this robust datasets:

- 1) Professor V. Panchapakesan, IIT Bombay,
- 2) Professor D. Chandrasekharam, IIT Bombay,
- 3) Professor G. N. Jadhav, IIT Bombay,
- 4) Professor Santana Banerjee, IIT Bombay,
- 5) Professor T. Ramkumar, Annamalai University,
- 6) Professor Alycia Stifall, Ohio University,
- 7) Professor Damian Nance, Ohio University,
- 8) Professor Kenneth R. Walker, University of Tennessee,
- 9) Professor Ed Perfect, University of Tennessee,
- 10) Professor Larry McKay, University of Tennessee,
- 11) Professor Robert D. Hatcher, University of Tennessee,
- 12) Ms. Melody S. Branch, University of Tennessee,

- 13) Dr. T. M. Mahadevan, Retired Director, Atomic Minerals Directorate, India,
- 14) Dr. S. Asokan, Former Chief Executive Titanium Project, TATA Steel, India,
- 15) Mrs. Hymavathi Sukumaran, granddaughter of TNM, living in Chennai, India,
- 16) Mr. T. N. Chandrasekaran, grandson of TNM, brother of Hymavathi, India,
- 17) Mrs. Lalitha Srinivasan, granddaughter of TNM, India,
- 18) Mr. Rajasekaran, Chennai, India,
- 19) Mr. S. Vaideeswaran, Atlanta, USA,
- 20) Ms. Geetha Vaideeswaran, Atlanta, USA,
- 21) Ms. T. Saraswathi, Sirkazhi, Tamil Nadu
- 22) Mr. K. Swaminathan, Founder and Patriarch of the Swathi Group of Companies, Chennai, Tamil Nadu, India.

I am so grateful to Dr. S. Asokan for providing meticulous and valuable review of the manuscript along with key photographs. As always, I thank Jean Shanmugam for her general comments. She has been helping in all my publication efforts for the past 45 years, since 1976. Finally, it must be acknowledged that this undertaking was severely hindered and delayed during data gathering in India but not stopped by the COVID-19 Pandemic worldwide!

### **Dedication**

I dedicate this compilation to the late D. Arumugam, who helped me financially during the critical period in my life (1960-1970) in India (Fig. 51). During that period, he, popularly known as “Mani”, paid for most of my expenses, such as, textbooks, college supplies, clothes, train tickets for commuting to Annamalai University (1962-65), wrist watch, even for movies, SEPM Membership Fees, Airline ticket to the USA, to list a few. When I was employed by Mobil in the USA, he was compensated in full and then some. Of course, he came to the Madras Airport to give me a send-off to the USA (Fig. 10).

### **In Memoriam: Dr. G. Venkatesan (Fig. 52)**

He was my half-brother (Fig. 8)

Place of birth: Sirkazhi, Tamil Nadu

Date of birth: 4 March 1933

Date of death: 15 May 2020

Place of death: Chennai

Education: M.A. Annamalai University

Ph.D. Sardar Patel University (SPU), Gujarat

Profession: Principal, Rajapalayam Rajus College, Rajapalayam

Relatives: Late V. Komalavalli, his wife

Mr. G. Rethinasami, his younger brother

Late R. Kalanidhi, Rethinasami's wife

Mr. V. Rajasekaran, his first son

Dr. V. Chandrasekaran, his second son

Ms. S. Santhi, his daughter (the twin of Chandrasekaran)

Dr. V. Anantharaman, his brother-in-law (wife's elder brother) (Fig. 10)

Dr. G. Shanmugam, his half-brother (Fig. 8)



Figures 1-52 cited in the text

**1**

### TNM Family Heritage

**TNM's**  
Father      Mother  
Their 11 Children

1. Mohambal
2. T. N. Vaidhyanathan
3. T. N. Kalidasan
4. Chellammal (a.k.a Kadavasa! Patti)
5. T. N. Muthuswami Iyer (TNM)
6. Parvathy
7. Kamakshi
8. Lakshmi
9. T. N. Subramaniam
10. Gowri
11. T. N. Viswanathan

Shri P.V.Naganatha Sasthry (1867-1930)  
Sanskrit Scholar & Lawyer (TNM's father)  
Meenakshi ammam (1875 -1925) (TNM's mother)

**Brothers of TNM**  
From L to R  
T. N. Kalidasa Iyer  
T. N. Viswanata Iyer  
T. N. Vaidyanatha Iyer  
T. N. Muthuswami Iyer (TNM)

**BLOG: SATTANATHAPURAM ROOTS**  
<http://snp-roots.blogspot.com/2008/08/thanjavur-p-v-naganatha-sasthri-1867-to.html?m=1>

**1A**

### TNM Family Tree

```

graph TD
    TNM["Professor T.N.Muthuswami Iyer (TNM)  
(1898-1980) 82  
T. R. Rajalakshmi-Wife  
(1907-1998) 91"]
    TNM --> Naganathan["Late T. M. Naganathan (Son)  
Air India & Alitalia  
Regional Manager"]
    TNM --> Venkatraman["Late T. M. Venkatraman (Son)  
Indian Airlines  
Commercial Manager"]
    TNM --> Meenakshi["Late D. Meenakshi (Daughter)"]
    TNM --> Nagalakshmi["Late Nagalakshmi (Daughter)"]
    
    Naganathan --- NAG["1 Son &  
3 daughters+  
grandchildren"]
    Venkatraman --- VEN["1 Son &  
1 daughter+  
grandchildren"]
    Meenakshi --- MEEN["4 Sons &  
2 daughters+  
grandchildren"]
    Nagalakshmi --- NAGAL["Died at young age"]
    
```

**Note:** Mr Naganathan booked my airline ticket to the USA by Alitalia in 1970

1B

### TNM Biography



Professor T.N. Muthuswami Iyer (TNM)  
(1898-1980) 82

**TNM: Biography and Legacy**

Place of Birth: Thanjavur, Tamil Nadu  
 Date of Birth: 28 June 1898  
 Date of Death: 10 December 1980  
 Degree: B. A. Hons, 1919, Geology  
 (University of Madras, Guindy Campus)  
 M.Sc., Geology, 1924? (Univ. Madras)  
 1924-1942: Lecturer/Professor  
 University of Madras, Guindy Campus)  
 1942-1953: Presidency College  
 Professor and Head, Geology  
 A classmate of Dr. M. S. Krishnan, who became  
 the First Indian Director General of  
 Geological Survey of India (GSI): 1951-1955  
 1955-1957: Sagar University  
 Worked with Eminent British Geologist  
 Dr. W. D. West, who established Applied  
 Geology at Sagar  
 1958-1966: Annamalai University  
 Professor and Head  
 TNM was a Fellow of the Indian Academy of Sciences  
 (F. A. Sc.)

1C

### TNM's 80<sup>th</sup> Birthday (1978)



2



**Presidency College  
Madras (Chennai)**



1. The Presidency College in Madras (Chennai), established in 1840 by the British, is one of the oldest colleges in India.
2. Prof. T. N. Muthuswami Iyer began his teaching career at the Presidency College in the 1942. He resigned from Presidency in 1953 and went to Sagar University.
3. His seminal mineralogical publications were published as the Fellow of the Indian Academy of Sciences from the Presidency College. (Muthuswami, 1949, 1951, 1953).
4. His early students at the Presidency were A. Parthasarathy (AP), S. Viswanathan (SV), and T. M. Mahadevan (TMM).
5. AP became the Head of Applied Geology, Civil Engineering, IIT Bombay.
6. SV became a Professor of Applied Geology, Civil Engineering, IIT Bombay.
7. TMM became the Director of Atomic Minerals Directorate (AMD).

Prof. T. N. Muthuswami Iyer, F. A. Sc.  
(1898-1980) 82

**Tetrahedral projection-ACF published by T. N. Muthuswami Iyer (1953)**

3

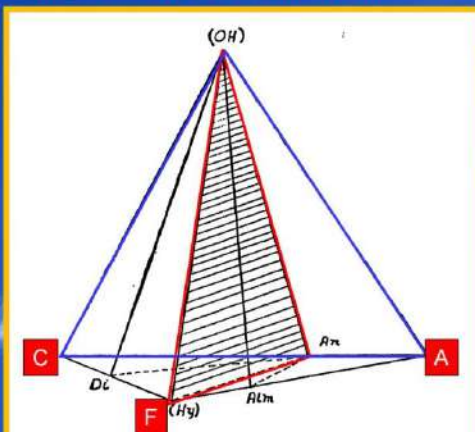
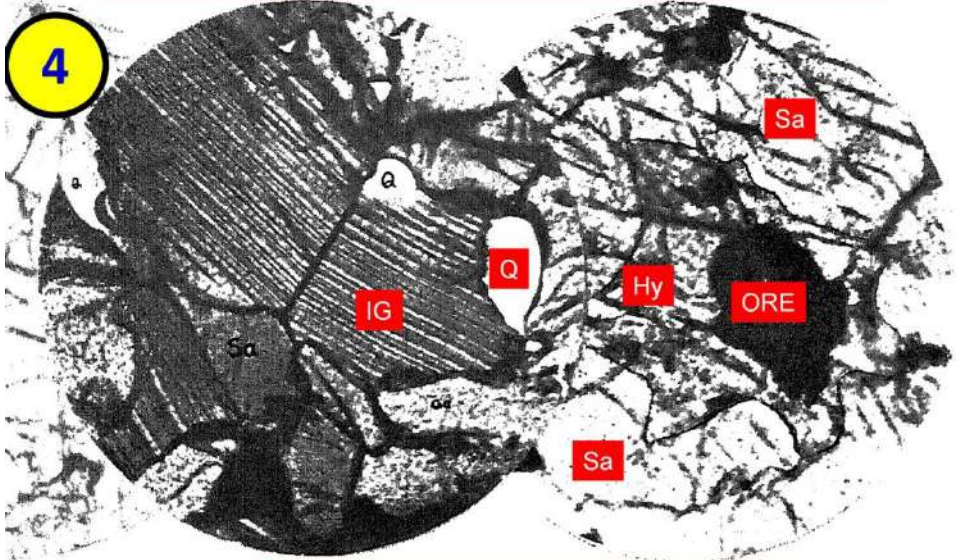


FIG. 4. Tetrahedral projection-ACF, with H<sub>2</sub>O at the apex

Note: Labels are highlighted by G. Shanmugam

Two micro-photographs published by T. N. Muthuswami Iyer in 1953



Herring-bone structure of intergrowth (IG)  
Quartz (Q), Salite (Sa), Hypersthene (Hy)  
From Muthuswami (1953)  
Note: Labels are highlighted by G. Shanmugam

5



**Sagar University**  
(Dr. Hari Singh Gour University)  
Madhya Pradesh, India  
Inaugurated in 1946

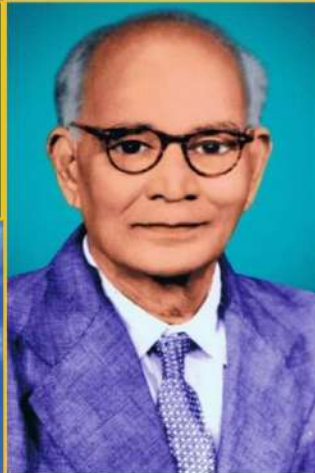
TNM resigned from the Presidency College and joined Sagar University in Madhya Pradesh, India during the mid 1950s. At Sagar, TNM worked with eminent geologic pioneers of India, such as Dr. William Dixon West. Dr. West, who earned his D. Sc. from the Cambridge University (UK), was the Director of Geological Survey of India in 1945. Furthermore, Dr. West established the Applied Geology Department at Sagar in 1951. At Sagar University, TNM presumably taught Crystal Optics, Mineralogy, and Petrology.

6

**G. Shanmugam**

After passing his B.Sc. In Geology With a First Class at Annamalai University, secured a position as a Science Teacher at a high school in Sirkazhi in the Summer of 1965

TNM motivated G. Shanmugam to quit his teaching job and pursue M.Sc. In Applied Geology at IIT Bombay



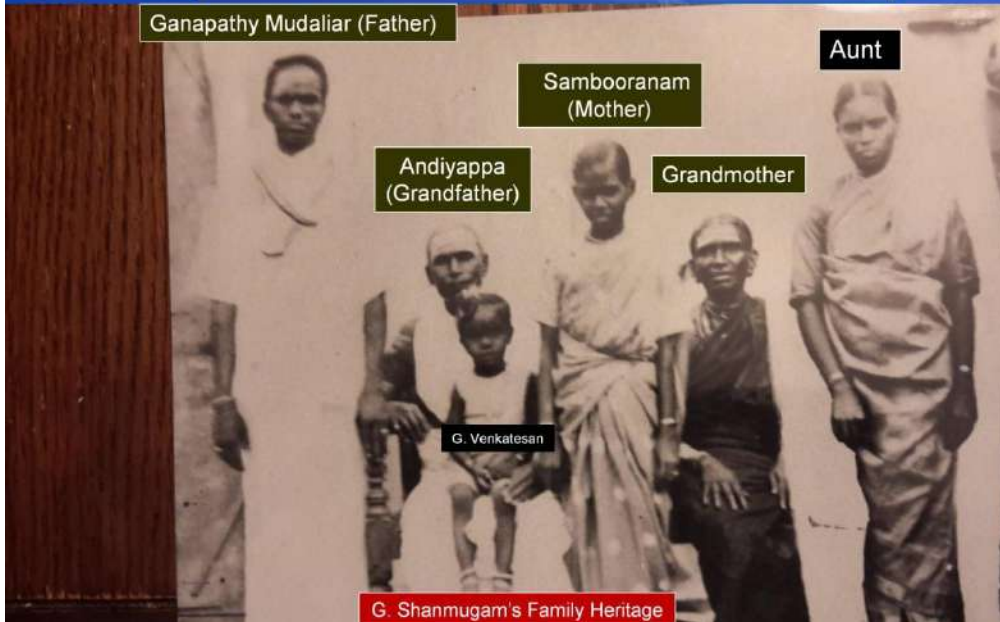
**Prof. T. N. Muthuswami Iyer, F. A. Sc.**  
**Fellow of the Indian Academy of Sciences**  
Chair, Geology Department  
Annamalai University  
1958-1966

7



8

A family photo of Andiyappa Mudaliar, Sirkazhi (1935)  
He was a wealthy diamond merchant  
Traded diamonds in Johannesburg in South Africa



9

I was born into a family of wealth.  
As a toddler, I was dressed up with  
all kinds of gold and silver jewelry  
by my grandmother



In the early 1950s,  
my family would suffer a  
devastating financial loss  
due to a major robbery  
at my father's  
jewelry store  
in Sirkazhi. This was a  
turning point  
that would propel  
me to education  
as the salvation  
from poverty

G. Shanmugam, 1947

10

HANDLING AGENTS FOR:  
**MALAYSIA SINGAPORE AIRLINES**

At the Madras Airport before departure to the USA, August 1970

K. Swaminathan

G. Venkatesan



V. Anantharaman D. Arumugam G. Shanmugam Father

11

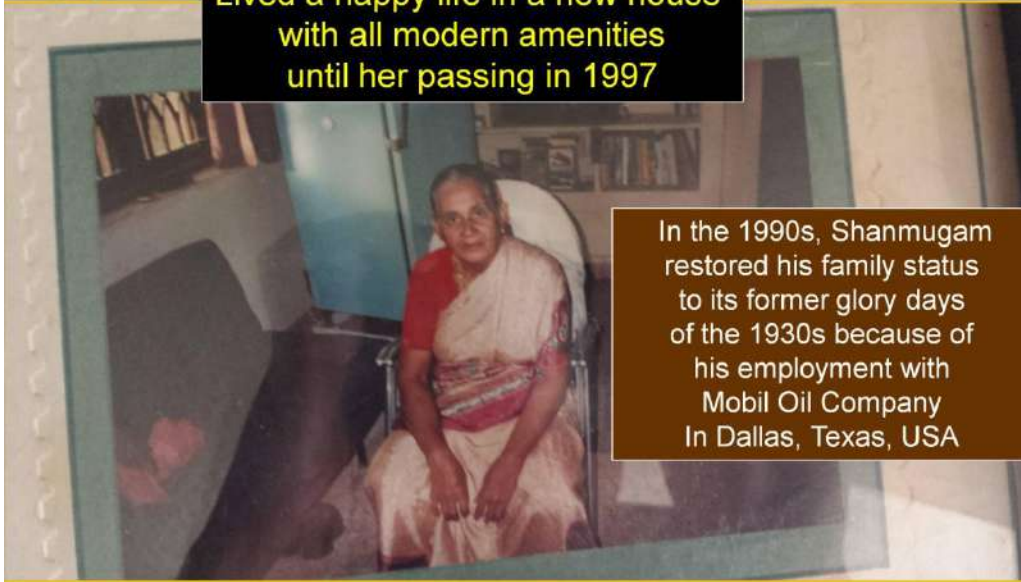
A family photo with Shanmugam sitting in the middle with white turban (1977)

Mother



12

**Mother (1995)**  
Lived a happy life in a new house  
with all modern amenities  
until her passing in 1997



In the 1990s, Shanmugam  
restored his family status  
to its former glory days  
of the 1930s because of  
his employment with  
Mobil Oil Company  
In Dallas, Texas, USA

**Annual Feeding of ~1000 Students per day in Sirkazhi: 1995-2003**  
(Despite its popularity, the programme ended due to local government regula

13



Started in memory of Shanmugam's younger sister Savithri, who died at age of 6



13A

A school bag with gift items (Pen, Pencil, Notebook, Sweets, Fresh fruits, Indian Rupees, etc) was distributed to each Participating student of a "Feast in Memory of the Late G. Savithri" (Shanmugam's deceased younger sister) Organized by G. Shanmugam in Sirkazhi, Tamil Nadu, India, 1995-2003



Label on the School bag is in Tamil Language:  
"Gift in Memory of the Late G. Savithri"

14

Post card from Professor T. N. Muthuswami Iyer, Former Head, Department of Geology, Annamalai University, to G. Shanmugam before his departure to Ohio University, Athens, USA.

Card date: 10-8-1970

59- First Main Road  
Raja Annamalaipuram- Madras-28: 10-8-70

My dear Shanmugam,

Very happy to see your kind letter. I am sure you will have a very successful and bright career in Ohio University. It is very good of you to think of me. Few people have this affection & regard.

I have permanently shifted to Madras. I am staying with my son Naganathan, who is Area Manager- ALITALIA. If you have to book your passage to OHIO he will do everything for you. His office address Area Manager- Alitalia- Mount Road. House address is that given above. House telephone No is 74468

Hope to meet you when you go next to Madras.

Yours sincerely

15



1958: Indian Institute of Technology Bombay (IIT Bombay) established



1989: A new building for the Department of Earth Sciences inaugurated



1964: Professor A. Parthasarathy as the Head, M.Sc. Applied Geology degree Programme under the Civil Engineering Department introduced



Professor Santanu Banerjee, Ph.D.  
Joined IIT Bombay in 1999  
Head of Earth Sciences since 2020

16

**G. Shanmugam**  
M.Sc., 1968  
Applied Geology  
IIT Bombay  
First rank, IIT Medal  
Petroleum Engineering  
Sedimentology  
Soil Mechanics  
Landslides  
ONGC Field Training in  
Rann of Kutch under  
Dr. S. K. Biswas

Dissertation Adviser of  
G. Shanmugam at IIT Bombay



**Professor A. Parthasarathy (1925-2015)**  
D.I.C., 1954 (Geology, Imperial College, London, UK)  
Ph.D., 1954 (Engg. Geology, London University, UK)  
Assistant Professor, Presidency College, Madras, India (1945-1959)  
Professor, Civil Engineering/Earth Sciences, IIT Bombay (1959-1985)  
Head, Applied Geology, Civil Engineering, IIT Bombay (1964-1982)  
Head, Dept. Earth Sciences, IIT Bombay (1982-1984)

17

Prof. A. Parthasarathy Retirement Day, 1985

Subbarao



Bhaskar Rao V. Pancapakesan S. Viswanathan. S. D. Shah A. Parthasarathy K. C. Sahu

17A

Prof. A. Parthasarathy celebrating Prof. S. D. Shah's retirement in 2002



18

### The T. N. Muthuswami Iyer-S. Viswanathan-D. Chandrasekharam Lineage



Professor  
D. Chandrasekharam, Ph.D.

1969: Professor D. Chandrasekharam (DC), as a student at the Presidency College, won the T.N. Muthuswami prize for top student.

1969-1972; DC was a student of Prof. Viswanathan at IIT Bombay.  
2000-2003: DC was the Head of Earth Sciences and invited Prof. Shanmugam to deliver a Colloquium Lecture at IIT Bombay, which Prof. Parthasarathy attended from retirement.

2015: DC and his wife celebrated the 90<sup>th</sup> birthday of Prof. Parthasarathy with Prof. Parthasarathy and his wife.  
Now retired from IIT Bombay.

For Awards and Publications visit: <https://www.geos.iitb.ac.in/dc/>  
2021: He is a Visiting Professor at IIT Hyderabad in Departments of Civil Engineering and Climate change.



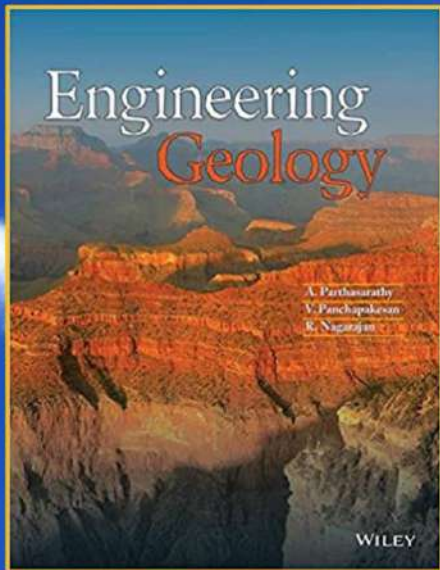
### INSTITUTE COLLOQUIUM DEEP-WATER PROCESSES AND TURBIDITE FACIES MODELS : A PARADIGM SHIFT BY PROF. G. SHANMUGAM ORGANIZED BY PROF. D. CHANDRASEKHARAM OCTOBER 1, 2003

D. Chandrasekharam G. Shanmugam



Credit: IITB Digital Archive

20



2013 Wiley Book  
**Engineering Geology**  
By  
A. Parthasarathy  
V. Panchpakesan  
R. Nagarajan  
ASIN : B078B25FMX

Professor Parthasarathy receiving cake from Mrs. Chandrasekharam



21

Prof. Parthasarathy offering cake to his wife



2015  
Prof. Parthasarathy's  
90<sup>th</sup> Birthday  
Celebration with  
Prof. Chandrasekharam  
and his wife at the  
Residence of Prof.  
Parthasarthy in Mumbai

22

### The T. N. Muthuswami Iyer-S. Viswanathan-G. Shanmugam Lineage



Professor S. Viswanathan, Ph.D.  
(1927-2016)

1. Professor S. Viswanathan was one of the early students of Professor T. N. Muthuswami Iyer at the Presidency College, Madras (Chennai).
2. In 1964, Prof. Viswanathan joined IIT Bombay as a faculty in the Civil Engineering Department.
3. In 1964, Prof. Parthasarathy and Prof. Viswanathan introduced the M.Sc. In Applied Geology program at IIT Bombay under Civil Engineering Department.
4. Professor Viswanathan was the first to earn Ph.D. degree in geology from IIT Bombay.
5. G. Shanmugam was a student of Prof. Parthasarathy, Prof. Viswanathan, and Prof. Panchapakesan at IIT Bombay (1965-68).
6. D. Chandrasekharam was a student of Prof. Viswanathan at IIT Bombay (1969-72).
7. Prof. D. Chandrasekharam was the Head of Applied Geology at IIT Bombay during 2000-2003.

Source: Chandrasekharam, D., and Mahadevan, T. M. 2012. Viswanathan, S. Obituary. *J Geol Soc India* 80, 591 (2012). <https://doi.org/10.1007/s12594-012-0179-8>

23

### The T. N. Muthuswami Iyer-V. Panchapakesan-G. Shanmugam Lineage



Professor V. Panchapakesan, Ph.D

1. Professor V. Panchapakesan was a student of Professor T. N. Muthuswami Iyer at Annamalai University during 1958-62.
2. In 1964, V. Panchapakesan joined IIT Bombay as Senior Technical Assistant in the Civil Engineering Department.
3. During 1965-68, he was a teacher of G. Shanmugam at IIT Bombay.
4. In 1976, he earned his Ph.D. in Geology from IIT Bombay.
5. In 1990, he was appointed as a full Professor in Applied Geology program at IIT Bombay.
6. In 2003, he retired from IIT Bombay.
7. In 2013, Prof. Panchapakesan co-authored a book on "Engineering Geology" with Prof. Parthasarathy.

2013 Wiley Book  
**Engineering Geology**  
By  
A. Parthasarathy  
V. Panchapakesan  
R. Nagarajan  
ASIN : B078B25FMX

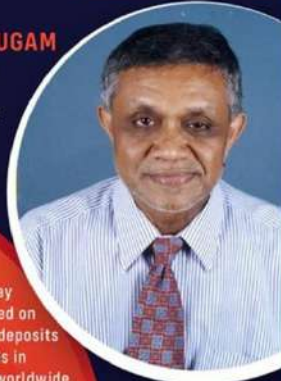
24



PROTOLITH '20  
GUEST SPEAKER

**Prof. G. (SHAN) SHANMUGAM**

An Adjunct Professor of Earth and Environmental Science at the University of Texas, Arlington, and the University of Tennessee, USA.



Protolith 20  
IIT Bombay

Prof. G. (Shan) Shanmugam is our alumni and a renowned iconoclastic sedimentologist. He did his Master's from IIT Bombay in 1968. Much of his work is focused on volumetric sandy-mass transport deposits and bottom current reworked sands in deep-water petroleum reservoirs worldwide. His work has spectacularly broken the widespread belief that most deep-water sands are turbidites. Prof. Shanmugam has received a nomination for the SEPM 2020 William Twenhofel Medal, a top award given each year to celebrate outstanding sedimentology contributions. Having several publications to his name, his challenging ideas and pragmatic approach have made him a stalwart of sedimentological discipline.



[www.protolith20.com](http://www.protolith20.com)

25

G. Shanmugam  
M.S. 1972, Geology  
OHIO University  
Petrographic study of  
the Ordovician  
Simpson Gp. Sandstones,  
Southern Oklahoma  
(Samples from Texaco Inc.)

Teacher of G. Shanmugam  
at Ohio University



**Professor Stanley P. Fisher (1919-1992)**  
Ph.D. (1952, Cornell)  
Chair, Geology Dept., Ohio U. (1970-75)  
Assoc. Dean, College of Arts & Sci. (1978-80)  
Gulf Oil Corp, South America

26

G. Shanmugam  
Ph.D., 1978, Geology  
Univ. Tennessee  
Middle Ordovician  
S. Appalachians  
Tectonics &  
Sedimentation

Teacher of  
G. Shanmugam at the  
University of Tennessee



**Prof. Kenneth R. Walker**  
Ph.D. (1969, Yale)  
The University of Tennessee,  
Chair: 1977-1987 (Geology)

27

G. Shanmugam  
Ouachita Mountains  
USA, 1975  
Ph.D. Student

Teacher of G. Shanmugam

**Professor Garrett Briggs**  
Ph.D. (1962, Wisconsin)  
Chair: 1972-1977 (Geology)  
Univ. Tennessee, Knoxville  
Secured Mobil Interview





Mobil

**28**

Mobil  
Field  
Research  
Laboratory  
(1978-1983)

Mobil  
Dallas  
Research  
Laboratory  
(1983-1992)

Mobil  
Technology  
Company  
(1992-2000)

**Mobil Research**

**1978-1983**

Australia  
New Zealand  
Alaska

**1983-1992**

Ouachita  
North Sea  
Norwegian Sea  
Nigeria  
China

**1992-2000**

Gulf of Mexico  
SE France  
Ecuador  
Gabon  
Brazi

**2000: Retired**

**29**

1981

Classic submarine fans  
 Tertiary, Spanish Pyrenees  
 Mobil Field Trip by Prof. E. Mutti

G. Shanmugam

R. J. Moiola

Photo by E. Mutti

30

Mobil  
Colleagues

**Managers**

G.K. Baker  
M.G. Bloomquist  
P. Braithwaite  
T. Cooley  
N.J. Guinzy  
E.L. Jones  
K.C. King  
A.J. Koch  
J.E. Krueger  
P.E. Luttrell  
S.J. Moncrieff  
R.J. Moiola  
P. Nixon  
M. Northam  
V.K. Oyofa  
R. Peacock  
M.P. Ramage  
S.E. Sommer  
J.W. Stinnett  
D.M. Summers  
P. Venuto

**Technologists Group 1**

K.A. Alhilali  
R. B. Bloch  
H.M. Chung  
R.T. Clarke  
J.E. Damuth  
D. Eby  
G. Eisenstadt  
J.R. Gormly  
J. Helwig  
J.B. Higgins  
C.T. Kalkomey  
D.W. Kirkland  
P.L. Kirkland  
R. Koepnick  
R.D. Kreisa  
M. Lee  
M.H. Link  
M.E. Mathisen  
J.G. McPherson  
H. Olson  
J.K. Sales  
J.F. Sarg  
E. Sprunt  
T. Tsui  
J. Vizgirda  
J.E. Welton  
J. S. Wickham  
M. O. Withjack

**Technologists Group 2**

J.M. Armentrout  
W.J. Beamish  
C. A. Clayton  
K.P. Dean  
R. Evans  
U. Ewherido  
S.B. Famakinwa  
S. Gabay  
W. Gardner  
W.E. Hermance  
R.J. Hodgkinson  
L.R. Lehtonen  
S. Malecek  
S.M. Mitchell  
P.H. Naylor  
J.O. Olaifa  
M. Poffenberger  
D.H. Rofheart  
C. E. Shepard  
K.E. Shields  
J.W. Snedden  
T.D. Spalding  
T. Straume  
S.E. Syevertson  
J.B. Wagner  
B.J. Welton  
G. Zimbrick

**Staff**

T. A. Allison  
P. Bell  
C. Branson  
S.L. Dunham  
S. Dykes  
J.T. Edwards  
R. Gilcrese  
A. Gonzales  
V. Goulet  
N. Houghton  
S.A. Kizer  
**M.K. Lindsey**  
J. Livermon  
A.F. Long  
D. Magill  
J. Mathews  
D.R. Miller  
A.S. Pearce  
M. Pearce  
B.J. Phillips  
N.D. Pine  
F.B. Roof  
S. Thomson  
C.M. Wall

30A

**1982 Mobil Geological Exploration Course Class Photo**



31

## G. Shanmugam

IIT Bombay, 1968  
Medal: First Rank Student  
in M.Sc. Applied Geology  
Civil Engg. Dept.



IIT Medal  
Top-Ranking Student  
Applied Geology  
Indian Institute of Technology  
Bombay  
1968



32

SUN TV Interview, Chennai,  
December 30, 2003  
"Vanakkam Tamizhagam"  
"Hello Tamil Nadu"  
By Ramesh Prabha



S. Ramesh

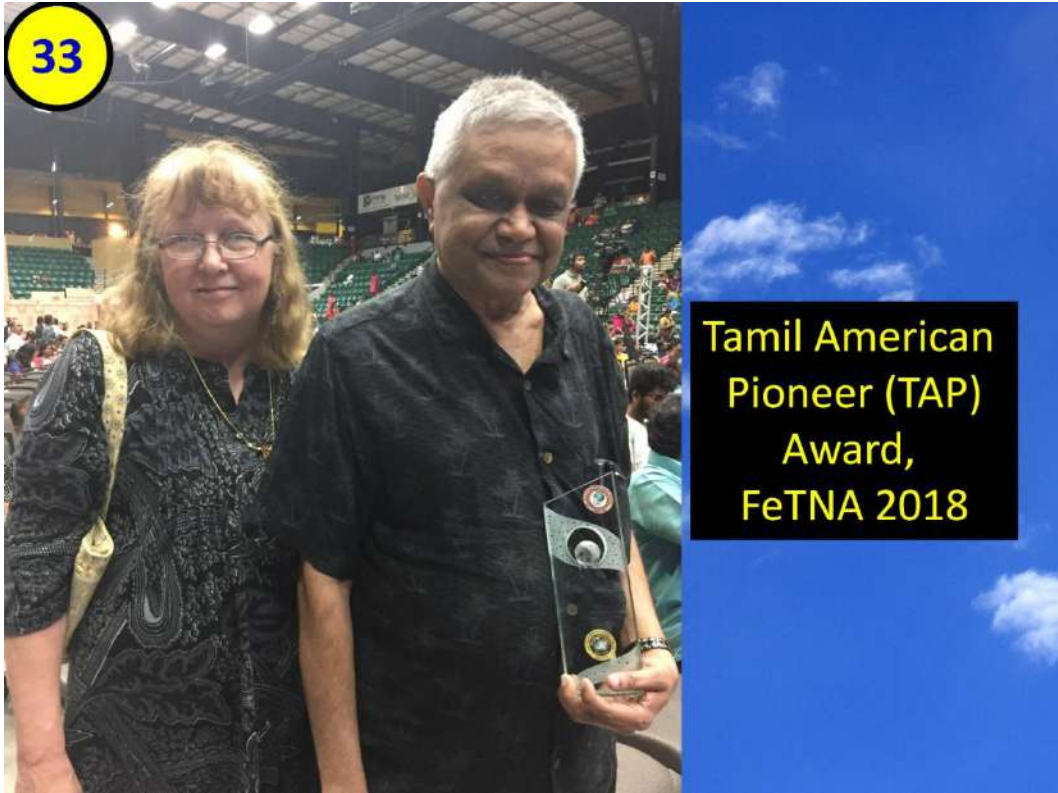
A. Balamurali

G. Shanmugam

Ramesh Prabha

Revathi

T. Saraswathi



34A



35

## Publications

Scientific works: 380

Elsevier Books: 3 (Deep-marine)

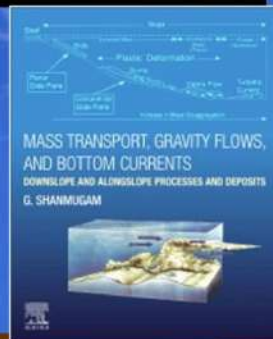
Chinese Editions: 2



2006



2012



2021

36

ELSEVIER  
Chinese Editions: 2



37

ONGC Deep-Water Sandstone Workshops



2002: Mumbai  
2002: Chennai  
2004: Kajurajo  
2009: Karaikal

Taj Palace Hotel  
Mumbai  
2002

38

Reliance Core House in Gadimoga  
(Inaugurated August 5, 2009)



39

Reliance Core Store



40

Reliance Core Workshop



40A

A T-Shirt was distributed to each Participant of the Reliance "Deep-water Rock Expo" Organized by G. Shanmugam in Kakinada, Andhra Pradesh India, 2006



Reliance Industries Ltd. (RIL) Managers:  
Anil Kumar, Rabi Bastia,  
Bhagaban Das & S. K. Shrivastava



Research Institute of Petroleum Exploration and Development (RIPED)  
Workshop on Global Deep-water Sedimentary Reservoirs  
PetroChina, Beijing, China, 2009

41



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China University of Petroleum, Qingdao, 2014

深水重力流沉积及非常规油气勘探培训班  
2014.5.12-14



43

## The T. N. Muthuswami Iyer-T. M. Mahadevan Lineage



**T. M. Mahadevan**  
Retired Director  
Atomic Minerals Directorate (AMD)  
Department of Atomic Energy  
Government of India



सत्यमेव जयते

1944-1949: T. M. Mahadevan, B. Sc. Honours (MA) and M.Sc (By Research), at Presidency College, was guided by Prof. T. N. Muthuswami Iyer (TNM). Some highlights are:

1. TNM introduced advanced courses in Map Drawing.
2. TNM introduced a four axis Federov Stage.
3. TNM published an English version of how to calculate Niggli values (German method).
4. TNM introduced students to the concept of mineral phases.
5. TNM made students to plot the analytical results published in the American Journal of Science by the school of Bowen in USA in the trilinear diagrams.
6. Dr W. D. West, the first Director of GSI after India's independence visited the department and greatly impressed by the curriculum developed by TNM.
7. After Mahadevan completed his B.Sc Honours course in 1947, Prof. TNM hired him as a research scholar.
8. TNM introduced Mahadevan to Dr. M. S. Krishnan (MSK) a renowned Geologist who was then a Suppdt. Geologist in GSI in charge of Madras office.

1949-1969: Mahadevan worked for the Geological Survey of India (GSI).

1969-1987: Mahadevan worked for the Atomic Minerals Division (AMD).

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## The T. N. Muthuswami Iyer-A. Parthasarathy-S. Asokan Lineage



Dr. S. Asokan (right) receiving "Distinguished Alumnus Award" at IIT Bombay in 2003 from Mr. Gopalakrishnan, Director Tata Sons.

Both Shanmugam and Asokan followed similar paths

1. Both were born in Sirkazhi, Tamil Nadu.
2. Both received their M.Sc. in Applied Geology at IIT Bombay.
3. Both were supervised by Prof. Parthasarathy at IIT Bombay
4. Both received their IIT Medal for top-ranking student in Applied Geology.
5. Both earned their Ph.D., Shanmugam from University of Tennessee (USA), Asokan from Cambridge University (UK)
6. Both have been successful in their professional careers.
7. Shanmugam excelled in publications and in the petroleum industry (see "70 Years of Knowledge Transfer" section above).
8. Asokan has been a Business Leader and a Geology & Mining professional.
9. 1975 – 1991. Corporate Head and General Manager of ACC (The Associated Cement Companies Limited), India.
10. 2003: Asokan was a Chief Executive Titanium Project, TATA Steel.
11. 2021: Shanmugam received University of Tennessee "Distinguished Alumnus Award".
12. 2003: Asokan received IIT Bombay "Distinguished Alumnus Award"  
<https://www.alumni.iitb.ac.in/en/awards/2003/distinguished-alumnus/dr-sundaresan-asokan>

The Story of K. Swaminathan-G. Shanmugam-S. Asokan from Sirkazhi  
Who earned M.Sc. in Applied Geology from IIT Bombay  
(Photo: Chennai 2016)

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46

G. Shanmugam and K. Swaminathan  
Chennai 2016



47

K. Swaminathan and G. Shanmugam  
 Palatial Residence of Swaminathan  
 T. Nagar, Chennai 2006



T. Saraswathi  
 (Sister of Shanmugam)

48

**TNM: Transformational, Neoteric and a Motivating teacher & a noble soul**



Prof. T. N. Muthuswami Iyer (TNM)  
 F. A. Sc.  
 (1898-1980) 82

TNM was the embodiment of Teaching, Novel ideas, Mentoring, Efficiency, and cultivating Ethics & Morality in students with a pioneering zest. He exemplified these core principles throughout his professional and personal life, be it:

1. Teaching Crystallography in classrooms,
2. Introducing and Operating E. S. Federov four-axis Universal stage microscope (which came into existence in 1892),
4. Calculating Niggli value in Normative Mineralogy,
5. Describing Madras Charnockites in Pallavaram, Tamil Nadu,
6. Publishing innovative mineralogical studies,
7. Documenting basic methods of geologic mapping,
8. Developing new curriculum in Geology in the 1940s and 1950s that India critically needed,
9. Keeping abreast of advances made in other countries (Russia, Germany, USA) with a view to keep knowledge transfer up-to-date in the Independent India,
10. Motivating students like me to aspire for new heights,
11. Maintaining an Intellectual honesty & heritage,
12. Demonstrating excellence in geosciences by his association with legends of Indian Geosciences, like Dr. W. D. West and Dr. M. S. Krishnan, and finally,
13. Raising a wonderful family with two successful sons and two daughters and grandchildren.

Therefore, the acronym "TNM" is just perfect for a Transformational, Neoteric and a Motivating teacher and a noble soul!

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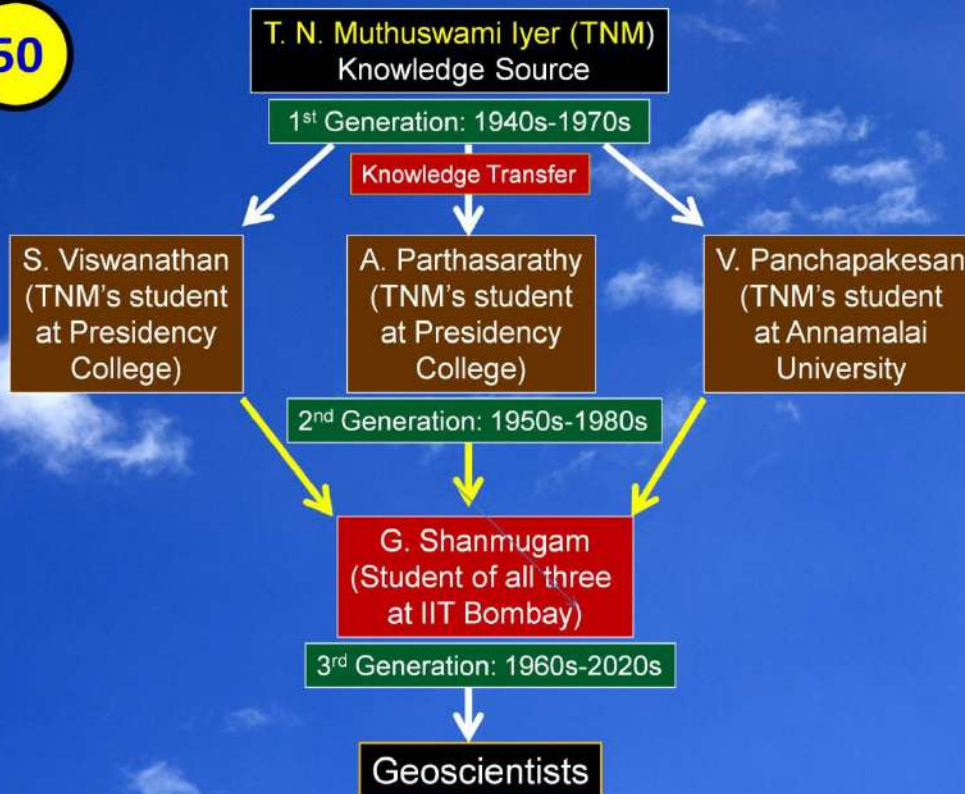
The T. N. Muthuswami Iyer-A. Parthasarathy-G. Shanmugam Lineage



1. Professor T. N. Muthuswami Iyer advised G. Shanmugam at Annamalai University to pursue his M.Sc. In Applied Geology at IIT Bombay.
2. Professor A. Parthasarathy, who was a student of Professor T. N. Muthuswami Iyer at the Presidency College in Madras (Chennai), supervised M.Sc. Thesis of G. Shanmugam at IIT Bombay.

Professor G. Shanmugam, Ph.D.

50



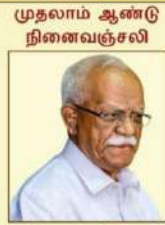
51

The Late D. Arumugam (1943-2003)



During the 1960-1970 period in India, my childhood friend Arumugam ("Mani") paid for my expenses, such as textbooks, college supplies, clothes, train tickets for commuting to Annamalai University (1962-65), wrist watch, movies, SEPM Membership Fees, Airline ticket to the USA, and many more. He was fully compensated by Shanmugam in the 1980s.

52

Dr. G. Venkatesan (1933-2020)  
(Dr. G. Shanmugam's half-brother)

வரலாற்று அறிஞர் பேராசிரியர்

**டாக்டர் க. வெங்கடேசன்**  
(04.03.1933 - 15.05.2020)

மாணவர்களின் மனங்கவர்ந்த வரலாற்றுப் பேராசிரியர் எண்ணற்ற வரலாற்று நூல்களைப் படைத்திட்ட வரலாற்றுஞர் மாணவர்களை மட்டுமல்ல தன் மக்களையும் உயர்நிலைக்கு உயர்த்திய உத்தமர் கற்றல்-கற்பித்தல்-படைத்தல் மூன்றும் தன் உயிரொச்சென வாழ்ந்தவர் தன் பொன்னுடனையும் மருத்துவ மாணவர்களுக்கே தானமாய் அளித்து விண்ணூலகம் சென்றவர்

அன்னாரை வணங்குகிறோம்  
தினையால் வாடும்

திரு ரத்னசாமி குடும்பத்தினர்  
திரு சண்முகம் குடும்பத்தினர்  
திரு ராஜசேகரன் குடும்பத்தினர்  
திரு சந்திரசேகரன் குடும்பத்தினர்  
திருமதி சாந்தி குடும்பத்தினர்  
திருமதி பொன் சொர்ணம்  
கத்தசாமி குடும்பத்தினர்  
திரு வர்த்தமானன் குடும்பத்தினர்  
மாணவர்கள் நண்பர்கள் உறவினர்கள்

Credit: Tamil Hindu India Edition  
(Published: 15 May 2021)

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#### **Appendix A: Selected PPT slides from the Ohio University Alumni Symposium Talk**

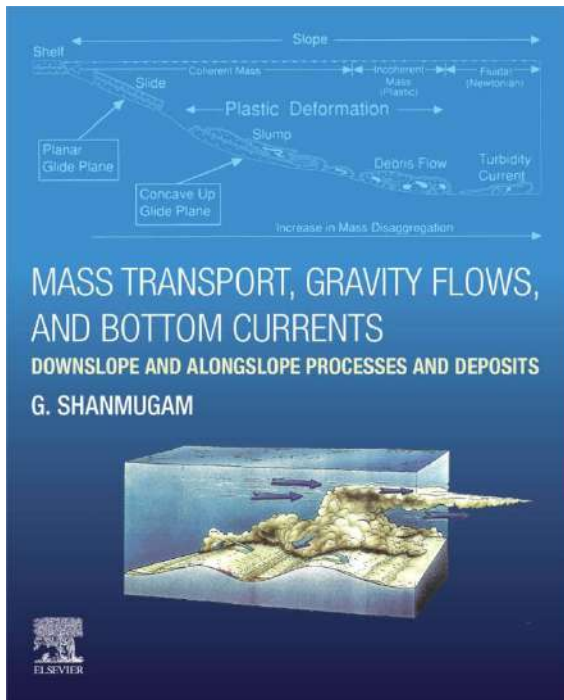
Talk is available on YouTube link:

[https://www.youtube.com/watch?v=v0n3mp\\_XQBY](https://www.youtube.com/watch?v=v0n3mp_XQBY)

**Recent advances in interpreting  
deep-marine deposits**

**G. Shanmugam, Ph.D.**  
(M.S. 1972, OHIO University)  
The University of Texas at Arlington

OHIO University  
Geological Sciences  
Alumni Symposium  
12.05 PM, ET, Saturday  
April 17, 2021



## History

Chain of Events  
During 56 years  
(1965 to 2021)  
That led to this  
Book and Talk

April 15, 2021  
J. Palaeogeography  
Review Article

## Event 6

I. M. Pei  
Louvre Pyramid  
1989



Bank of China  
1990



Mobil Field Research Laboratory (1978-1983)



Mobil Dallas Research Laboratory (1983-1992)



Mobil Technology Company (1992-2000)

## Mobil Research

1978-1983

Australia  
New Zealand  
Alaska

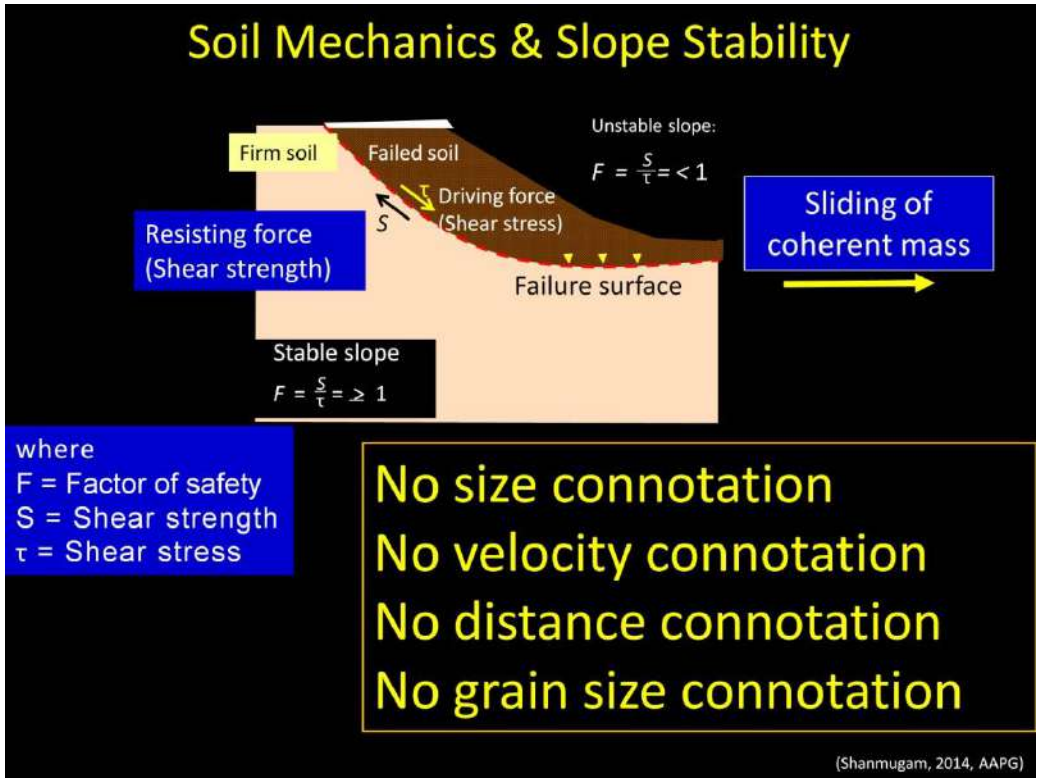
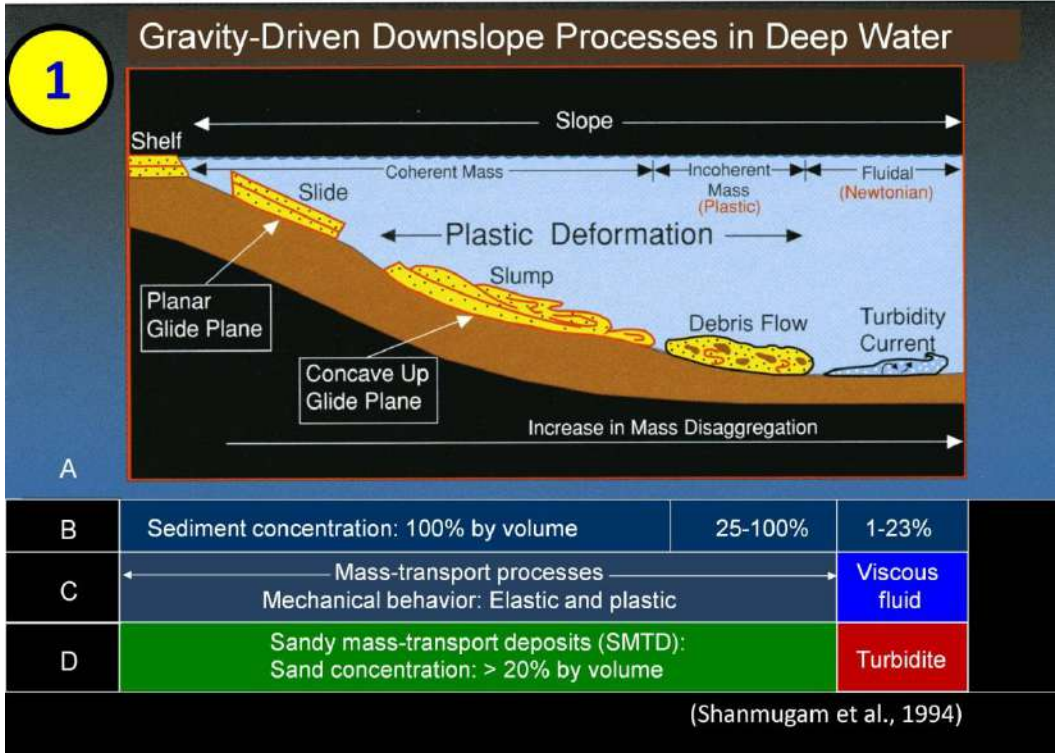
1983-1992

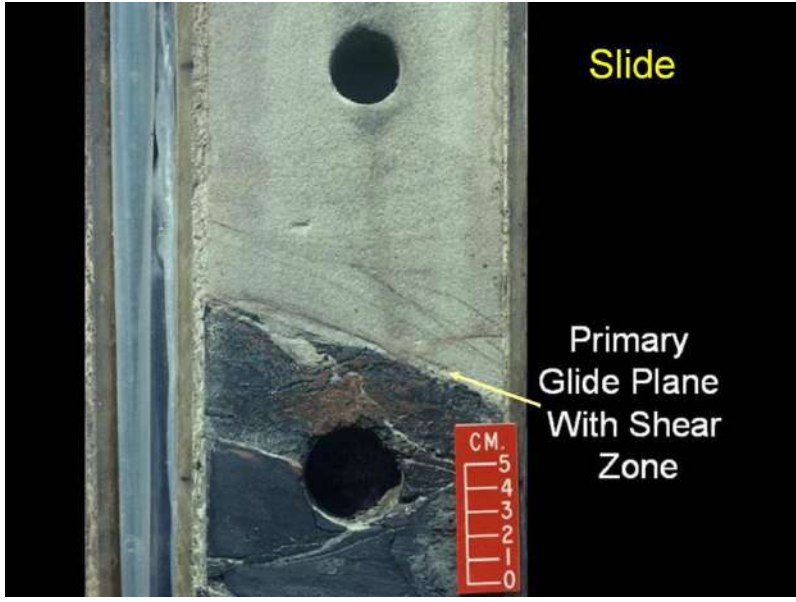
Ouachita  
North Sea  
Norwegian Sea  
Nigeria  
China

1992-2000

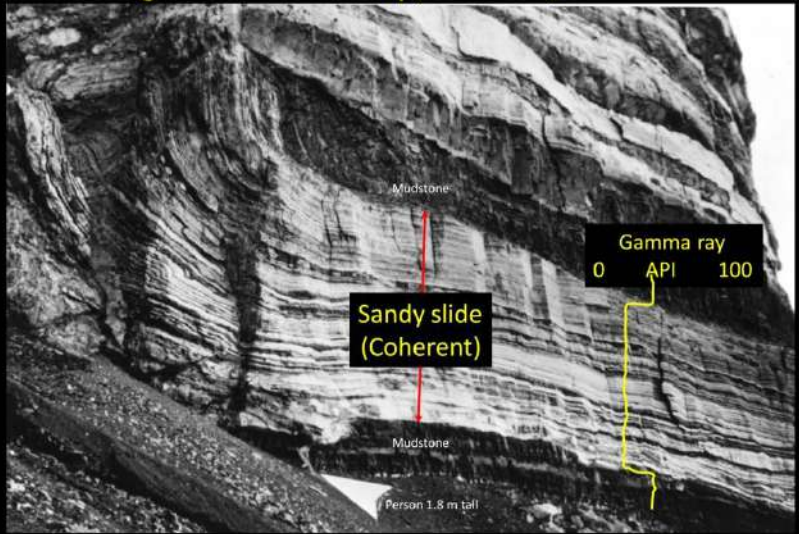
Gulf of Mexico  
SE France  
Ecuador  
Gabon  
Brazi

2000: Retired





Recognition on outcrop, Jurassic, Antarctica



(Macdonald et al., 1993)

**2**

### Seismogenic slump folds Dead Sea Basin

Slump folded  
Undeformed

Undeformed  
Slump folded  
Undeformed

Slump folded  
Undeformed

(Alsop and Marco, 2013)

Undeformed sandstone

Slumped sandstone and mudstone

Sedimentary Slump  
Eocene  
La Jolla  
California

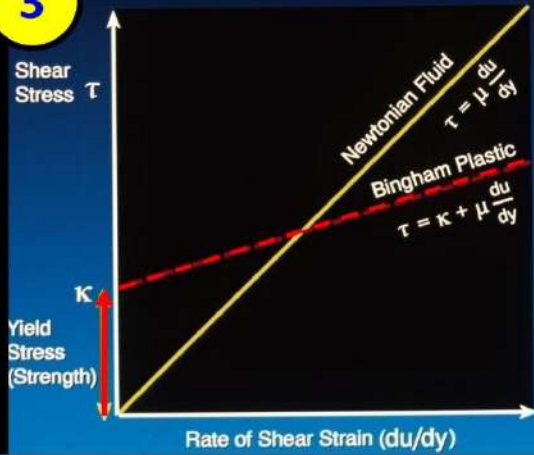


# Fluid Mechanics

## Rheology

### Stress - Strain Relationships of Newtonian Fluid and Bingham Plastic

3



Reynolds Number:

$$R = \frac{\rho u D}{\mu}$$

$R > 2000$  = Turbulent  
 $R < 500$  = Laminar

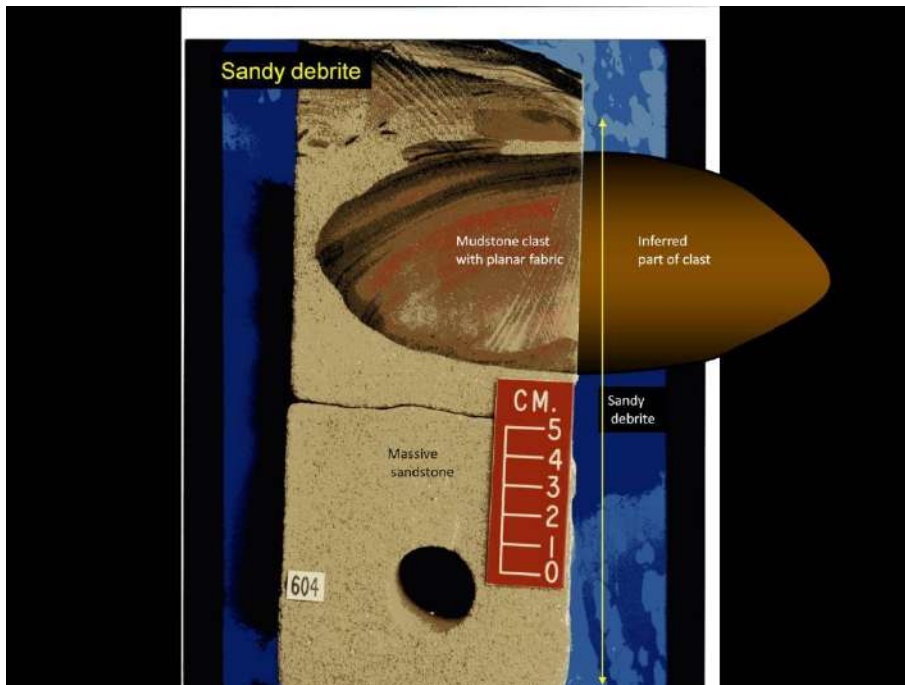
Bingham Number:

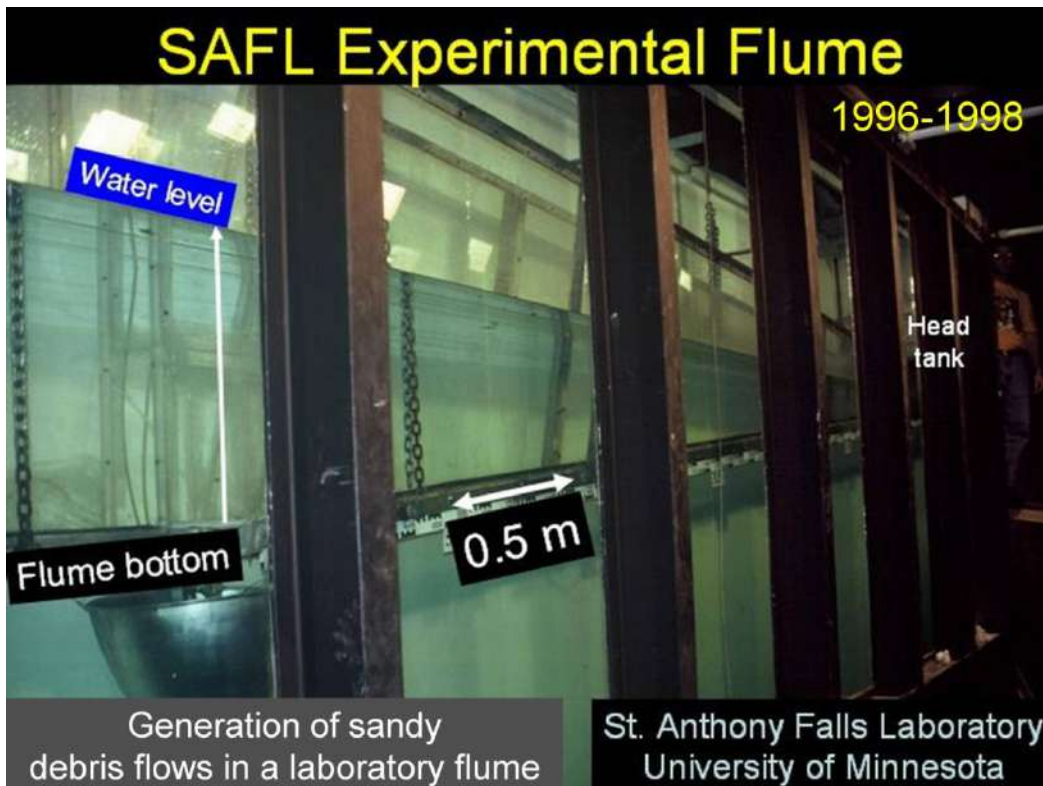
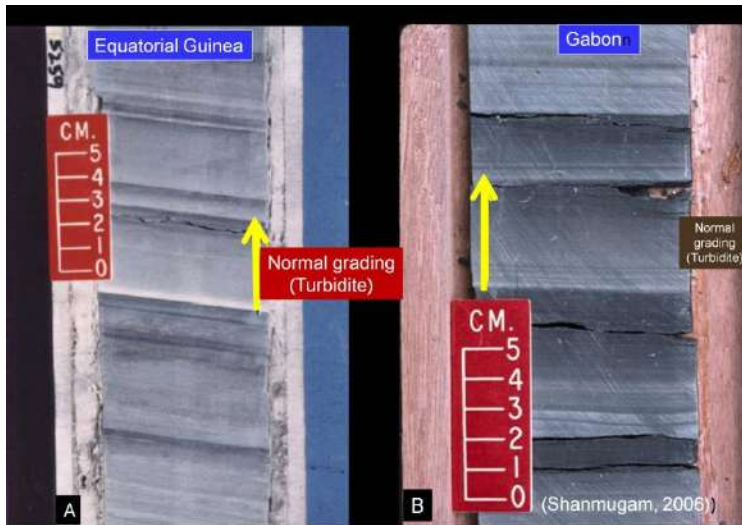
$$B = \frac{\kappa D}{\mu u}$$

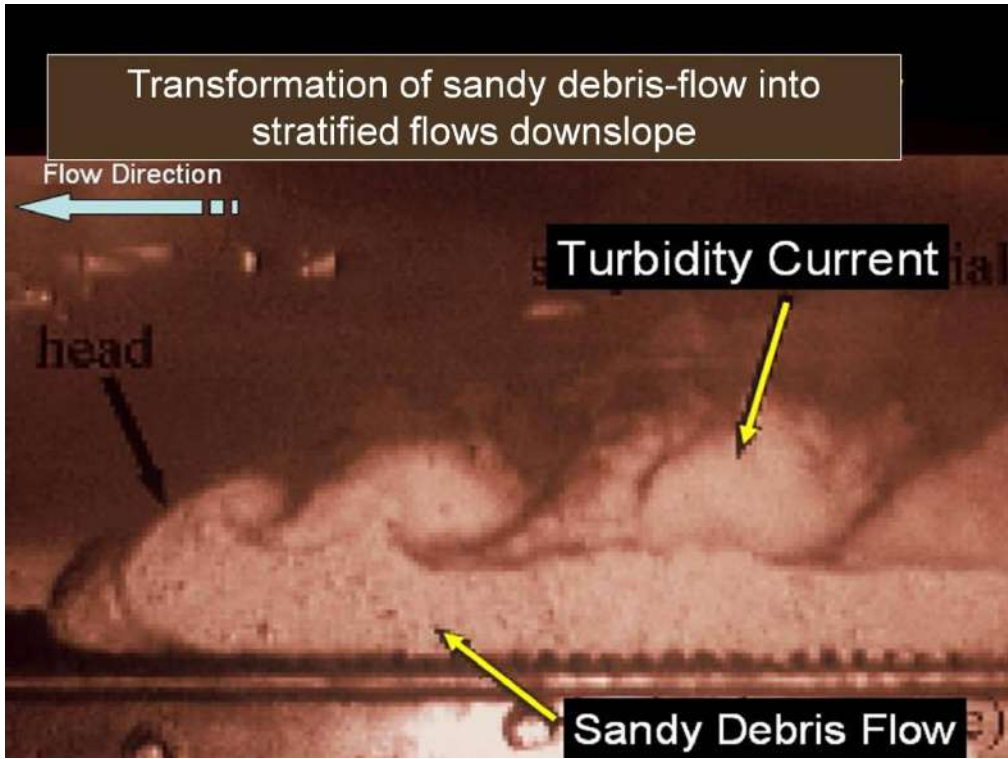
$R \approx 1000B$  = Turbulent  
 $R/B = \rho u^2 / \kappa \approx 1000$  = Turbulent

$\kappa$  = Strength  
 $\mu$  = Viscosity  
 $\rho$  = Density  
 $u$  = Velocity  
 $du/dy$  = Rate of Change of Velocity  
 $D$  = Flow Thickness

(Shanmugam, 1997)

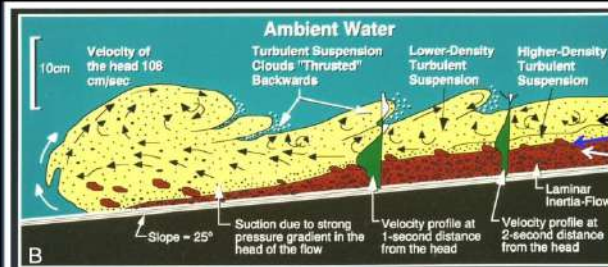
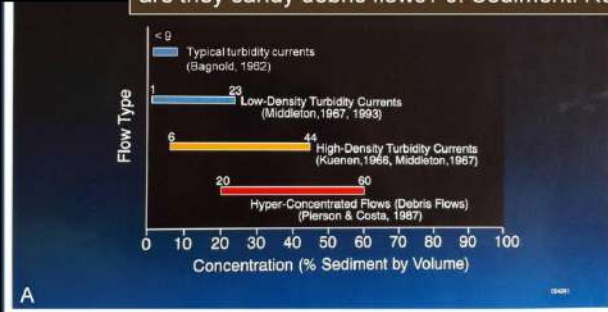






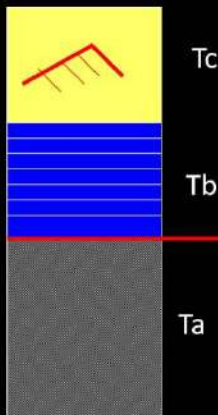
**Orthodoxy:** HDTC are coarse-grained turbidity currents

Shanmugam, G., 1996. High-density turbidity currents: are they sandy debris flows? *J. Sediment. Res.* 66, 2–10



Labels added in this Article by G. Shanmugam:  
 Turbidity current  
 Clast along rheological interface  
 Sandy debris flow

## Problematic Transition from $T_a$ to $T_b$

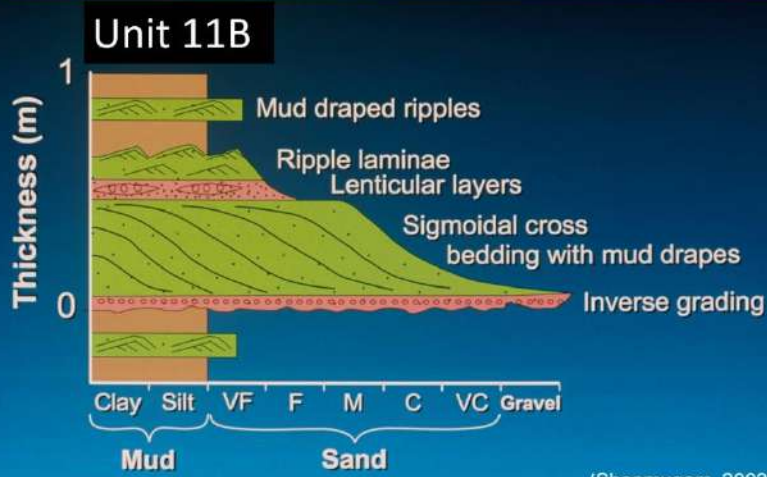


*"...the debate on the upward change from massive ( $T_a$ ) to parallel laminated ( $T_b$ ) sand in a Bouma-type turbidite remains unresolved."*

(Leclair and Arnott, 2005)

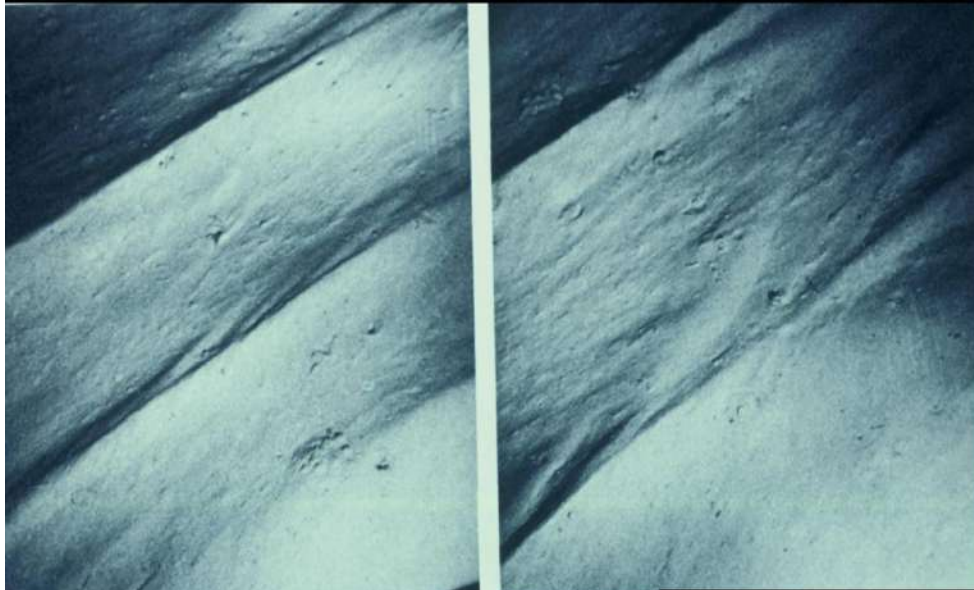
# Annot Sandstone

## Sigmoidal Cross Bedding



(Shanmugam, 2002)

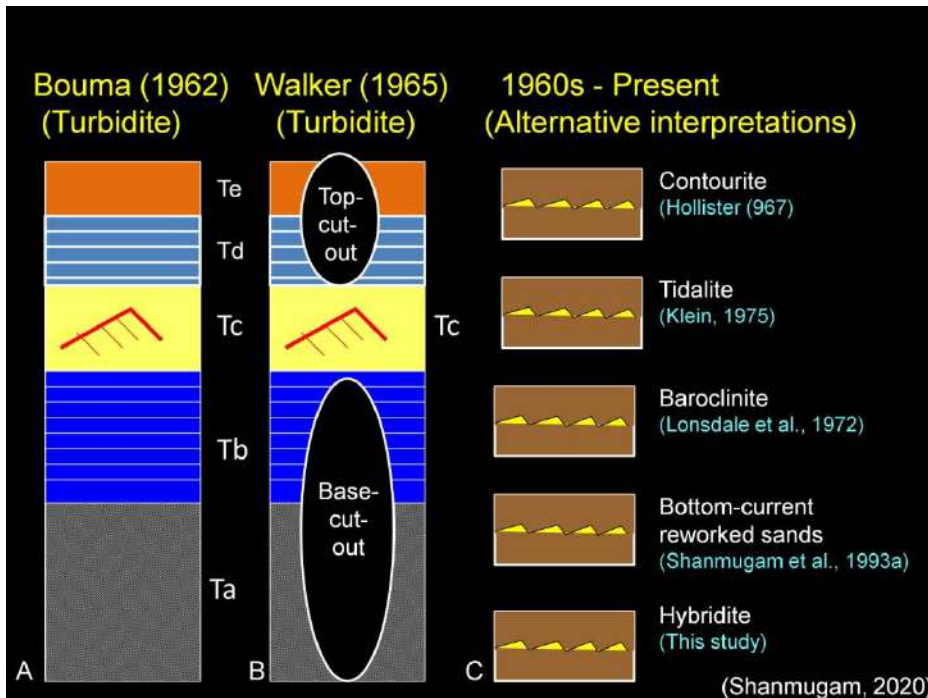
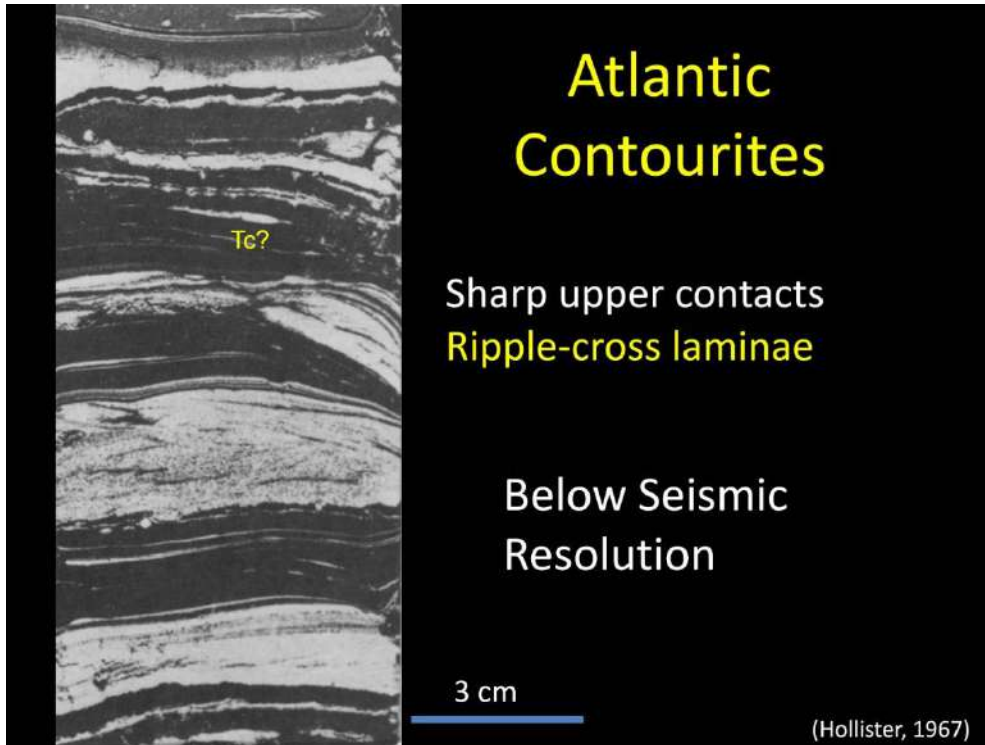
### Longitudinal Ripples by AABW, 4845 m, Mozambique Abyssal Plain, Off S. Africa



29°21'S 40°08'E

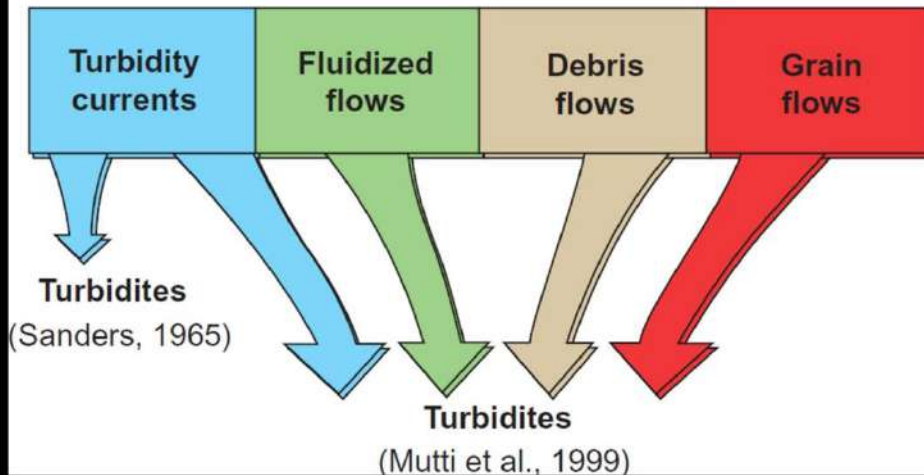
29°21'S 40°08'E

(Heezen and Hollister, 1971)



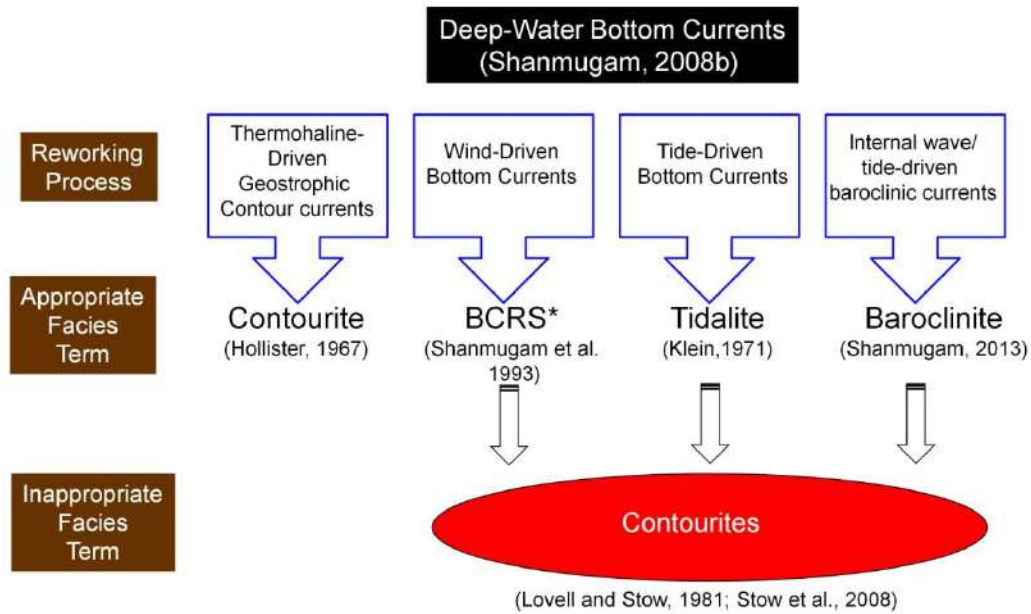
## Sediment-gravity flows

(Middleton and Hampton, 1973)

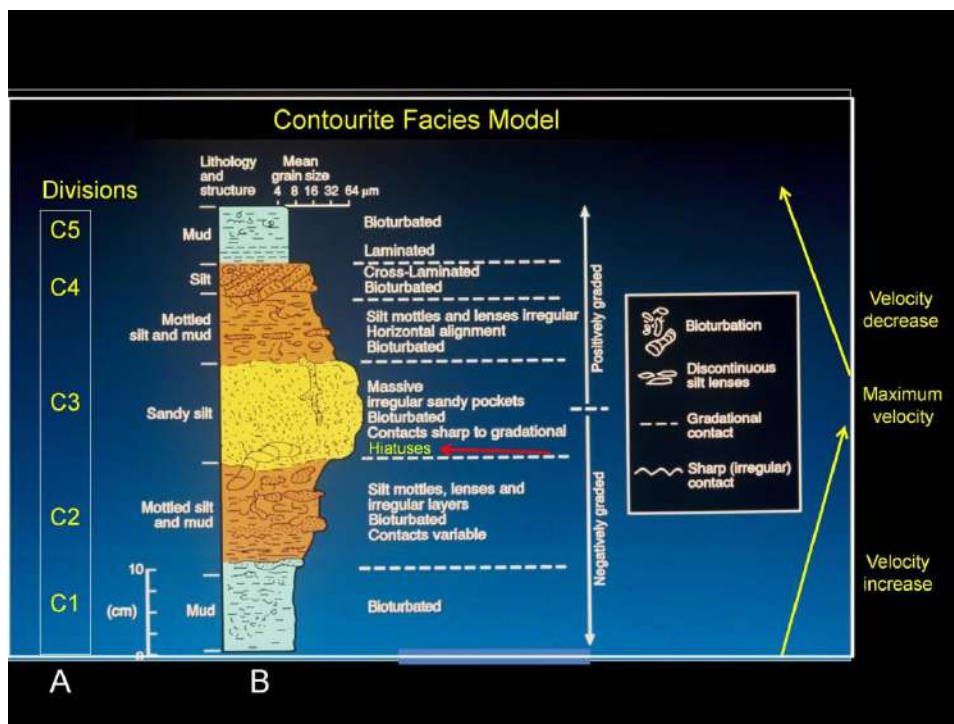


Types of hyperpycnal flows			Flow origin	
Non-Newtonian (plastic)		Cohesive debris flows (CDF)	High-density short-lived flows entering the basin	
Newtonian (Fluid flows)	Supercritical	Hyperconcentrated flows (HCF)	- Alluvial fans - Small mountainous rivers - Flash floods	
		Concentrated (granular) flows (CF)	Require steep slopes to accelerate, incorporate ambient water, and transform into dilute turbulent flows	
	Subcritical	Sediment-laden turbulent flows (SLTF)	Pebbly	Low-density long-lived flows entering the basin
			Sandy	- Medium- to large-size rivers
Muddy			No steep slopes are necessary. Flow can travel for long distances since the flow is sustained by the river discharge	

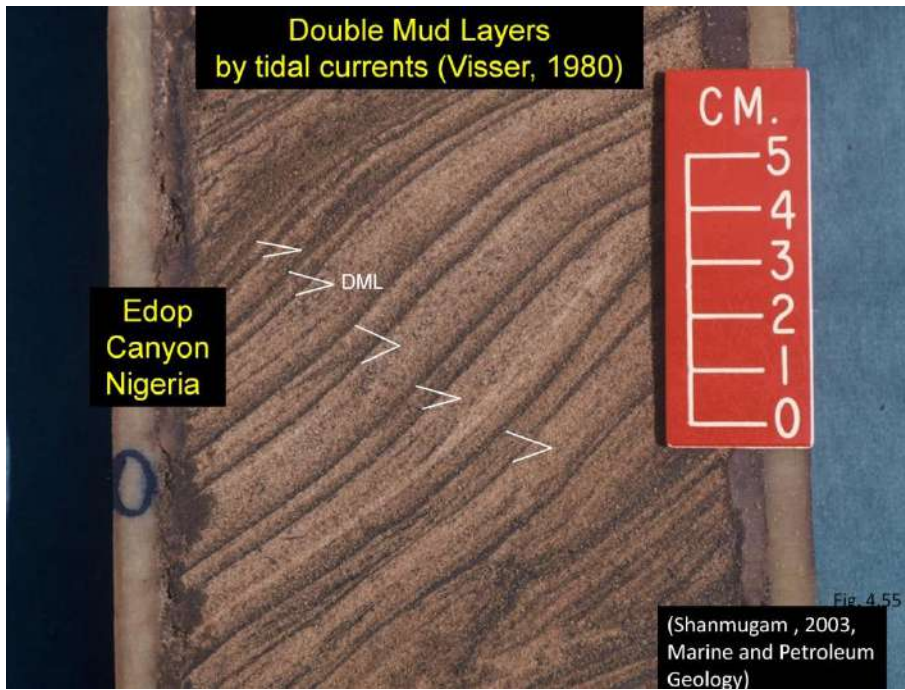
(Zavala, 2020)



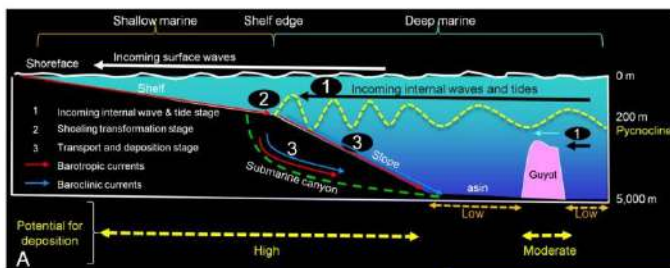
\*BCRS = Bottom-current reworked sands. This general term is appropriate for all four types.





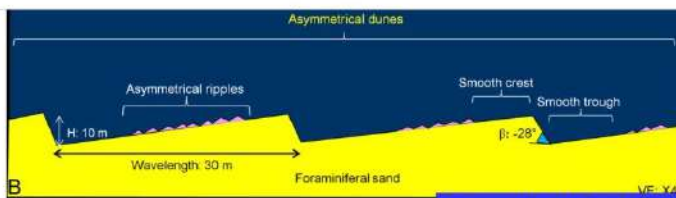


### Baroclinic Depositional Model

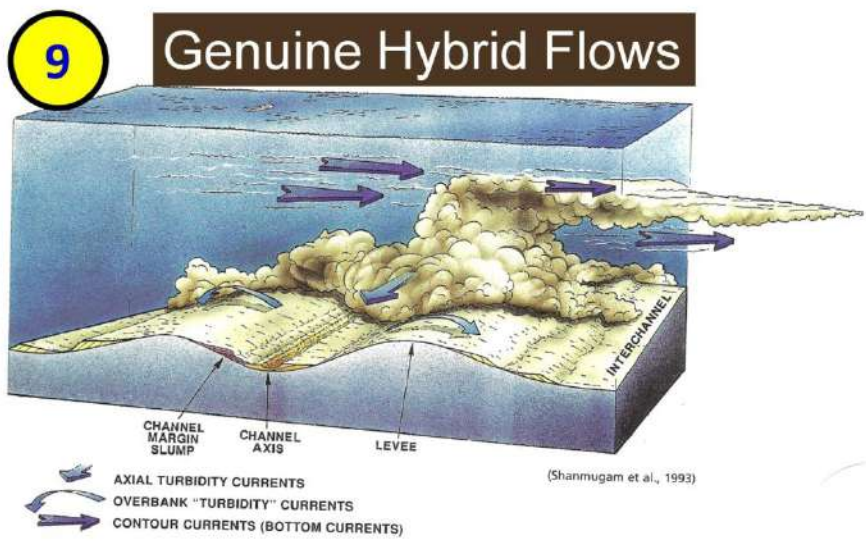


(Shanmugam, 2013)

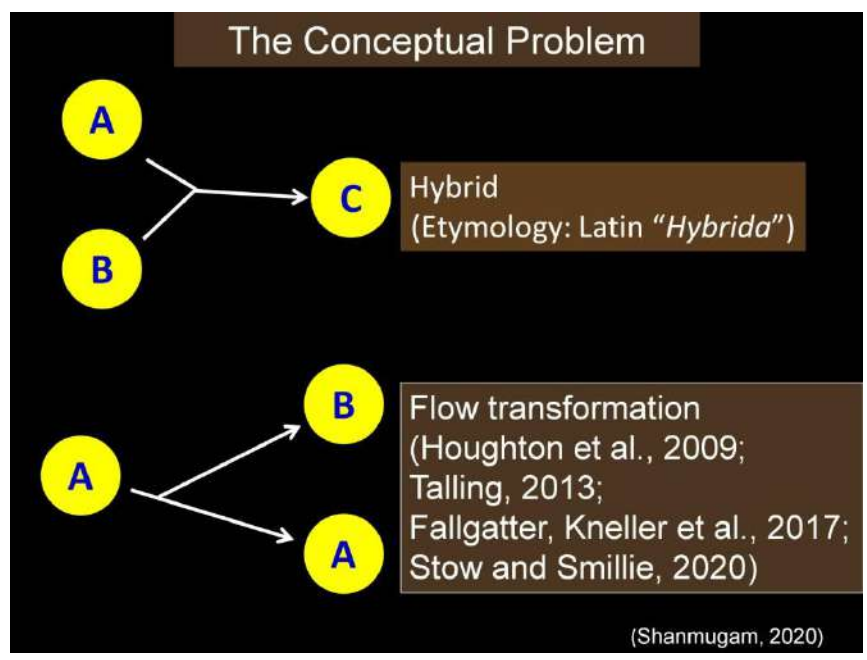
### Baroclinic Traction Bedforms Horizon Guyot, Mid-Pacific Mountains

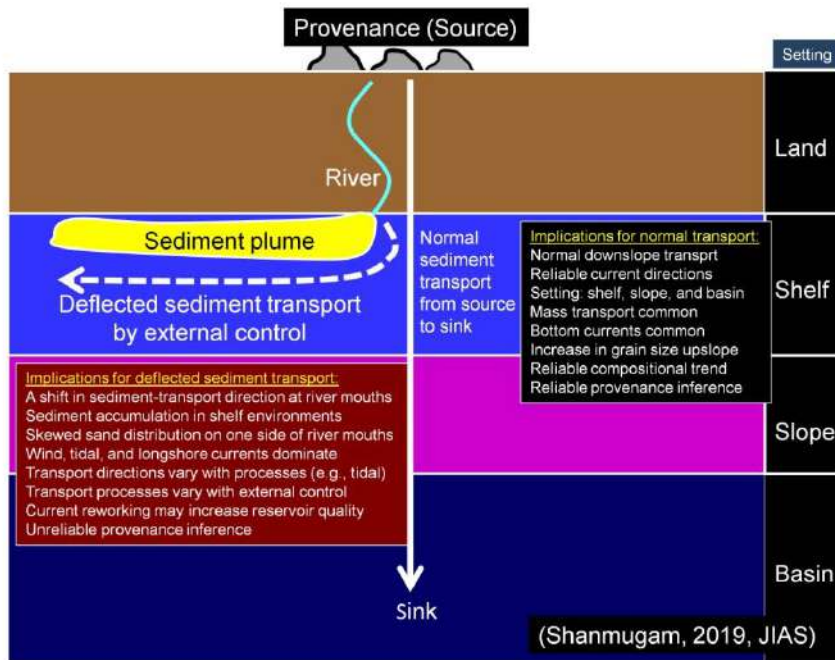


(Lonsdale et al., 1972)

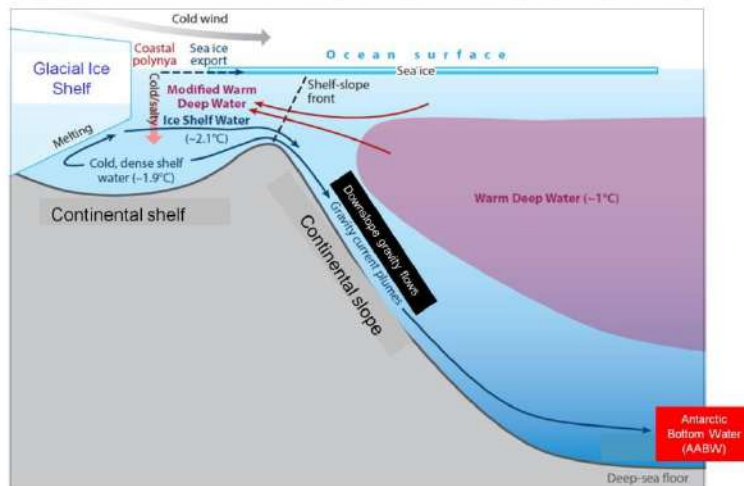


(Shanmugam et al., 1993, AAPG)





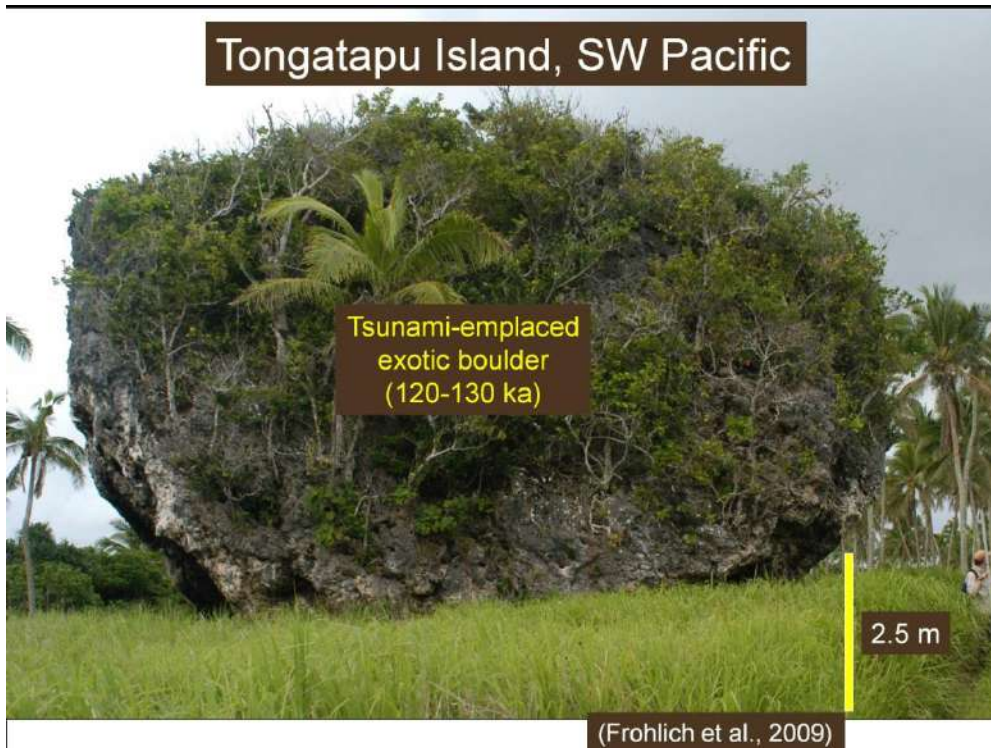
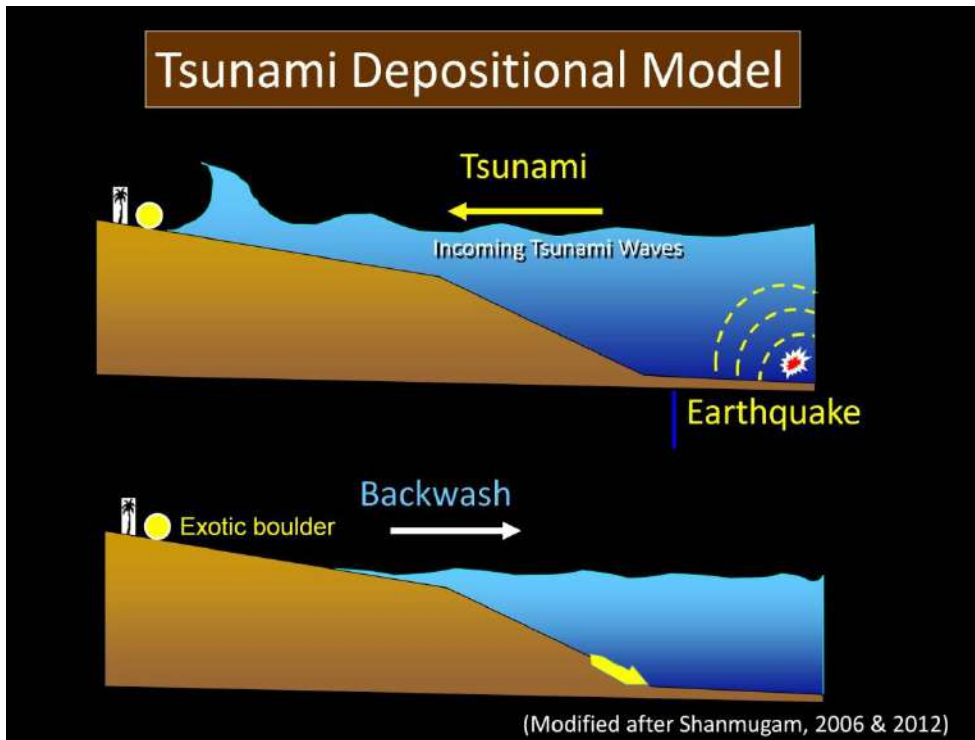
**Origin of Antarctic Bottom Water (AABW) as downslope gravity flows**

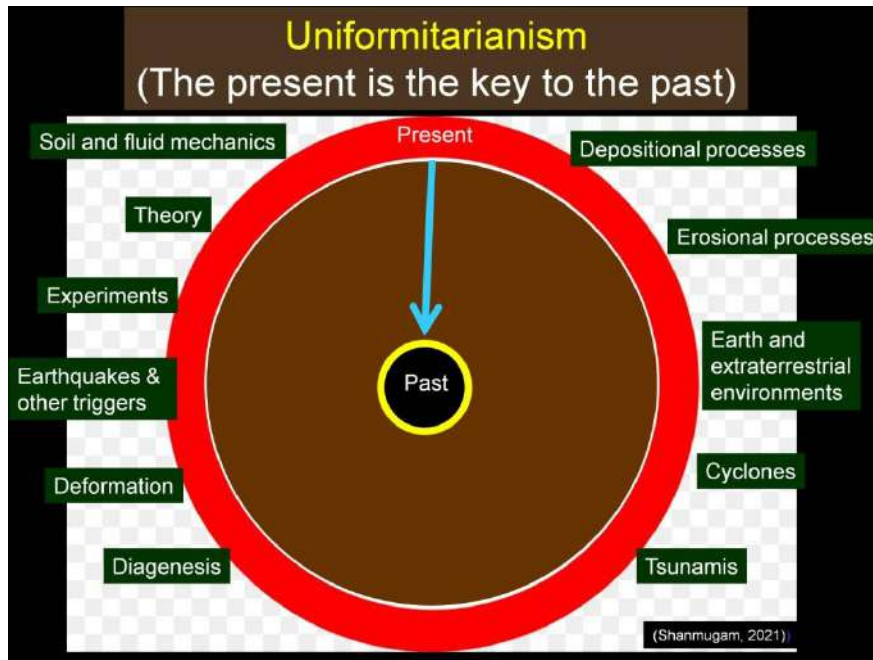


Modified after Gordon (2013) and Purkey et al. (2018)

**Gravity Flows (Shanmugam, 2020, JIAS)**

Flow Direction	Shelf	Slope	Basin	Flow Dynamics	Comments
Downslope (Sediment transport & deposition)	1. Hypopycnal flow			Density of river water > Density of basin water Single-layer flow Double-layer flow Multi-layer flow	Mud Absence of sediment core from modern environments Facies model unreliable
	2. Turbidity current			Sediment-gravity flow Flow turbulence Newtonian rheology Turbulent state C < 9% by volume Deposition by settling	Fine grained sand and mud Sharp base Normal grading Gradational top Facies model unreliable
	3. Debris flow			Sediment-gravity flow Matrix strength Plastic rheology Laminar state C: 25-100% by volume En masse freezing	Gravel, sand and mud Projected clasts Floating clasts Planar clast fabric Inverse grading
	4. Liquefied/Fluidized flow			Sediment-gravity flow Upward moving fluid Liquefaction Plastic rheology C: > 25% by volume	Fine- to coarse- grained sand Fluid-escape structures Dish and pillar structures Dewatering lips Soft-sediment deformation structures (SSDS)
Alongslope (Sediment reworking)	5. Grain flow			Sediment-gravity flow Frictional strength Grain collision (Dispersive pressure) Plastic rheology C: 50-100% by volume	Fine-grained sand Well sorted Thin layers (< 5 cm) Massive sand Inverse grading
	6. Thermohaline contour current			Downslope gravity flow Alongslope contour current Sustained current No sediment transport Current reworking	Sand and mud Cross laminae Current ripples Parallel laminae Facies model unreliable





## Lessons Learned

1. Soil & fluid mechanics (Basics).
2. High-density turbidity currents (Debris flows).
3. The Bouma Sequence (Obsolete).
4. Turbidite, contourite & hyperpycnite (Confusion).
5. Origin of deep-marine ripples (No criteria).
6. Double mud layers & sigmoidal cross bedding (Tidal).
7. Hybrid flows (Mixing, not flow transformation).
8. Deflecting plumes (Wind forcing/external control).
9. Tsunami exotic boulders (No criteria).
10. Uniformitarianism (Solution).
11. Deep-marine: a new frontier (M.S. and Ph.D. Topics).

## Acknowledgements

### Acknowledgments

Jean Shanmugam, Manuscript Quality Control (Since 1976)  
Dr. R. J. Moiola, Mobil, Dallas, Texas, USA (1978-2000)  
Mobil Oil Company, Dallas, Texas, USA (1978-2000)  
St. Anthony Falls Lab., U. Minn., USA (1996-1998)  
Reliance Industries Ltd., Mumbai, India (2002-2010)  
Res. Inst. Pet. Expl. Prod., Petrochina, Beijing (2009-2010)  
Oil & Natural Gas Corp., Dehra Dun, India (2003-2010)  
Prof. Alycia Stigall, Chair, OUGS (2021)  
Prof. Damian Nance, Dist. Prof. Emeritus, OUGS (2021)  
Ms. Cherri Sheets, Ohio University (2021)  
Mr. David Johnson, OU Office of Gift Planning (2021)  
Mr. Travis Esbenshade, Weaver Consultants Group (2021)  
Mr. S. Vaideeswaran, Atlanta, USA (2021)  
Alumni Symposium Participants (April 16-17, 2021)

**THANK YOU ALL!**

### AAPG Bulletin Cover Photos by G. Shanmugam

Pulpit Rock, Norway      Karst, China      Granitic Boulder, S India

The image displays three covers of the AAPG Bulletin. The left cover features a photograph of a tall, dark rock formation (Pulpit Rock) overlooking a body of water. The middle cover shows a landscape with green, rounded karst hills (Karst, China). The right cover depicts a large, dark, rounded boulder (Granitic Boulder, S India). Each cover includes the AAPG logo and the title 'Bulletin'.

Thanks.  
Cheers,  
Shan  
Dr. G. Shanmugam  
May 19, 2021

The End