The Importance of Establishing a Stratigraphic Nomenclature for Petroleum Exploration: A Case Study from Tanzania*

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Abstract

To manage their energy sector effectively, national governments need to make informed decisions, reduce risk, and build a clear energy policy. For this, it is important to have excellent knowledge of national petroleum and geothermal resources. Their size and accessibility are key drivers in answering resource policy questions, negotiating private sector contracts for investment, and building an integrated gas value chain. Accurate, good quality, and reliable subsurface data are crucial for performing these assessments and to determine the availability and amount of geo-energy available. With any given subsurface data, it is imperative that it is standardized. A stratigraphic nomenclature is an important standardization tool for subsurface activities, providing a 'geological language' to adequately describe relationships between rock units. It forms the basis for all subsequent subsurface work and is vital for making resource assessments and informed decisions on exploration and development plans. A stratigraphic nomenclature in essence is a naming convention, an agreement between stakeholders to use the same names and age relationships for lithological units that occur in the subsurface of a particular region. As such, it is an important prerequisite for discussions among stakeholders concerning geological issues, such as e.g. the distribution of a source rock or a reservoir unit. Its relevance is even more obvious in the field of governance. In Tanzania, activities related to hydrocarbon exploration and development are expanding rapidly and the need for a stratigraphic nomenclature is apparent. Because of this, the Tanzania Stratigraphic Nomenclature (TSN) project was initiated in 2015. As the prime stakeholder, TPDC is overall responsible for the development of the TSN, while PURA will act as its custodian once it is finished. TNO acts in a supporting and capacity building role towards both TPDC and PURA. External stakeholders, such as the operators, universities, and government bodies, play an important role in providing essential input and feedback. One of Tanzania's major challenges is to build enough capacity and knowledge to fulfil the responsibilities of making resources assessments, assessing exploration and development plans, and manage the country's data and information on the subsurface. Therefore, the underlying project aims to address both capacity building and to provide a solid basis for data management.

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The Importance of Establishing a Stratigraphic Nomenclature for Petroleum Exploration

A Case Study From Tanzania

Roel Verreussel, Sander Houben, Friso Veenstra*

TNO/Geological Survey of the Netherlands

ECN › TNO innovation for life

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Agenda

1. Introduction – TNO / Geological Survey of the Netherlands
2. Africa Focus
3. Case Study: Tanzania Stratigraphic Nomenclature project

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1. **Introduction – TNO / Geological Survey of the Netherlands**
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TNO – Who we are

- Founded in 1932 by act of parliament
- Non-profit and independent position
- 3,000+ professionals, turnover of ~€ 400 M (US$ 450 M)
- Focus on applied scientific research
- Operating in “golden triangle”

- **The Geological Survey of the Netherlands is a division of TNO Energy**

An overview of TNO / Geological Survey of the Netherlands

- Center for knowledge of the subsurface and its applications
- National repository of all subsurface data

- Independent consultant to Ministry of Economic Affairs
- Involved in geo-technical work and policy support
- Well-trained staff, as part of the larger TNO research organisation

- **High-quality database is the core of all good work**
- **Focus on consultancy and practical knowledge transfer, also internationally**

Agenda

1. Introduction – TNO / Geological Survey of the Netherlands
2. **Africa Focus**
3. Case Study: Tanzania Stratigraphic Nomenclature project

TNO and Africa

- Over the past few years we have identified and assessed the needs for specific capacity requirements at government level in various African countries

- We have discussed these capacity needs with potential beneficiaries and stakeholders looking at collaborative opportunities across the region

- Our approach is to work with key government institutions and organizations to formulate and carry out plans helping to build a stronger energy sector that can achieve inclusive sustainable growth

Lots of external drivers

- Developing newly discovered (offshore) resources is a way to improve energy access and to reduce poverty
- One of the main challenges for the governments involved is to build technical expertise and institutional capacity for professional management of the growing energy sector
- **Governments need reliable subsurface information and proper resource assessment**

With major challenges ahead

- Ideally, the size and locations of natural resources need to be defined, national records of volumes, reserves and resources, and the remaining potential should be as clear as possible

- Data management capabilities and database technology should be fully developed, while storage facilities are an important component of the database too

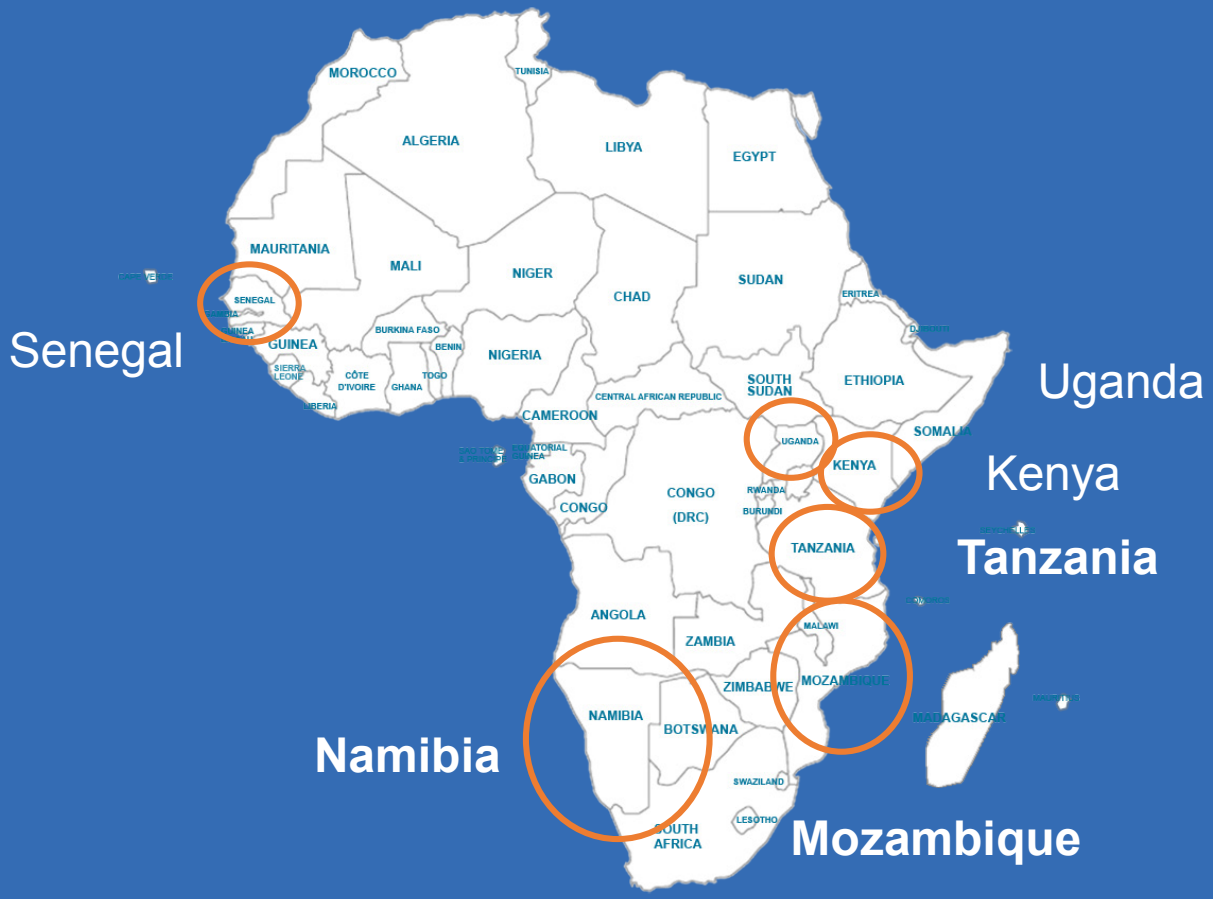
- Collaboration and coordination between individual stakeholders should be stimulated and perfected to the extent possible

What we do and how we do it

1. Geomodelling & joint research
2. Data management / consultancy
3. Government advisory

- Tailored delivery mechanisms, including local presence
- Capacity enhancement and knowledge transfer
- Co-creation – Stratigraphic nomenclatures as prime example

Regional overview



Agenda

1. Introduction – TNO / Geological Survey of the Netherlands
2. Africa Focus
3. **Case Study: Tanzania Stratigraphic Nomenclature project**

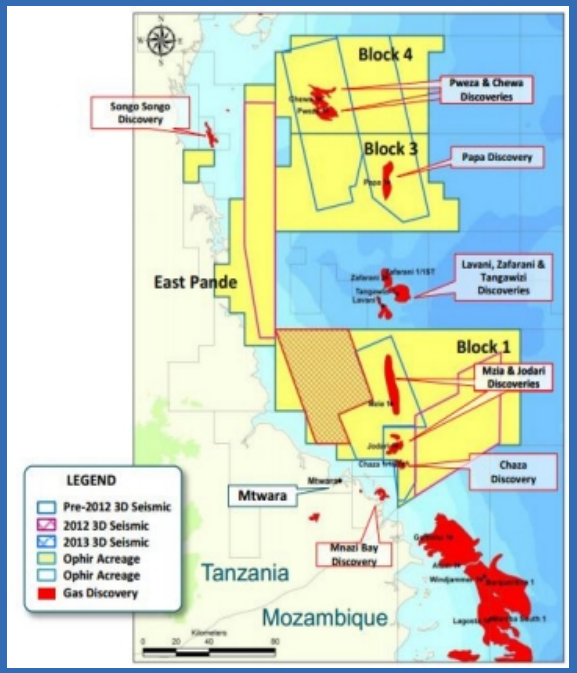
Project goals and rationale

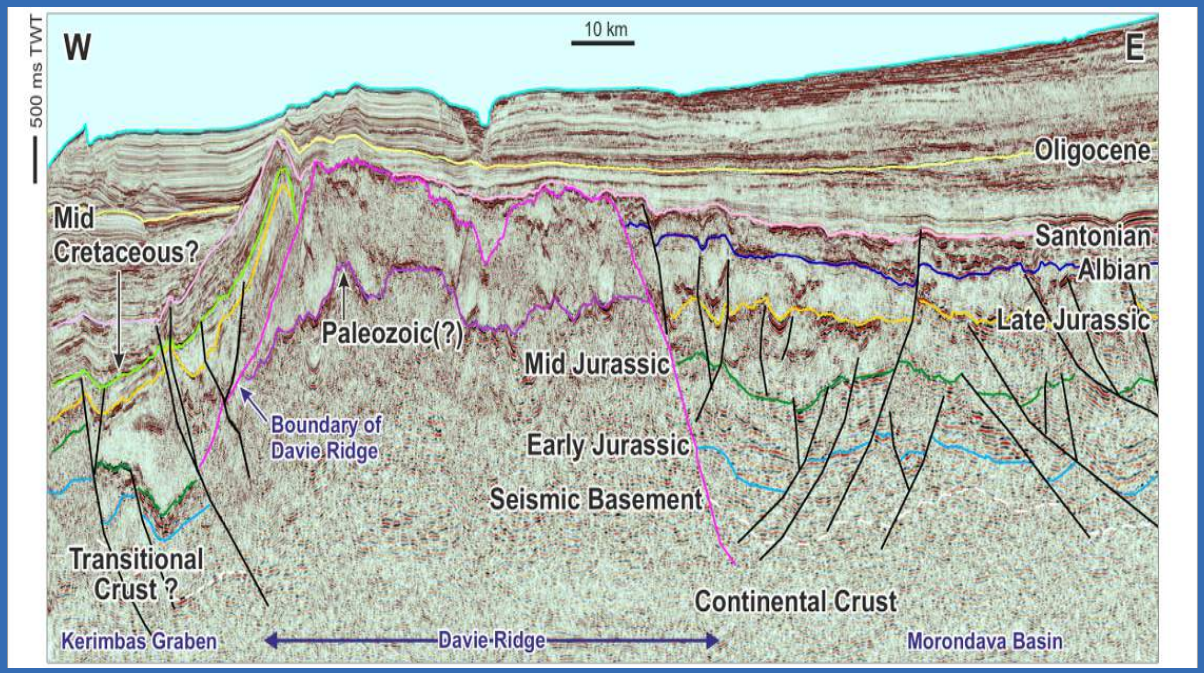
- Support national governmental organizations to develop and maintain the Tanzania Stratigraphic Nomenclature, connecting the onshore with the offshore geology
- Capacity enhancement in all aspects related to the development, maintenance and publication of the stratigraphic nomenclature

- **A national stratigraphic nomenclature contributes to good governance of the subsurface sector and maximizes revenues from Tanzania's subsurface resources**

Tanzania has a dynamic geology

Offshore petroleum systems





Onshore petroleum systems

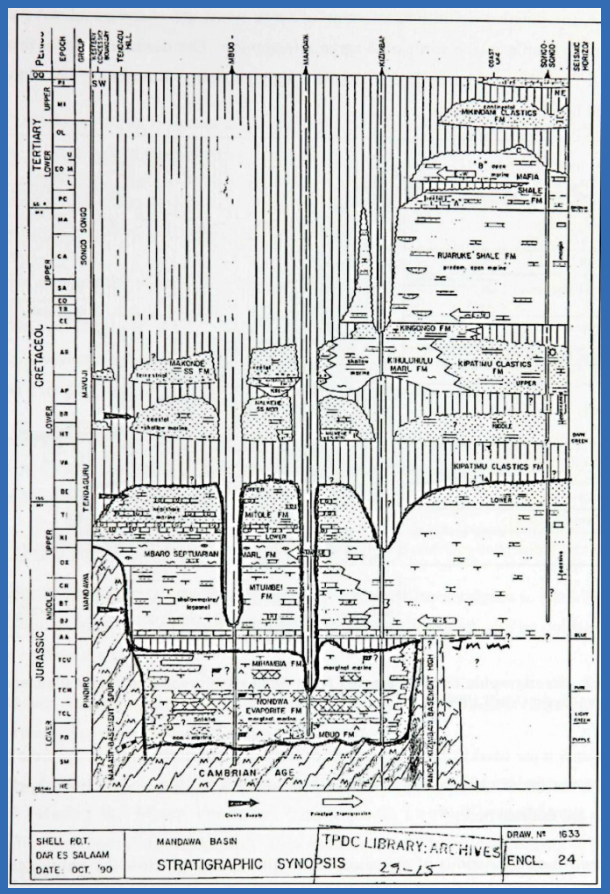
There is some early work

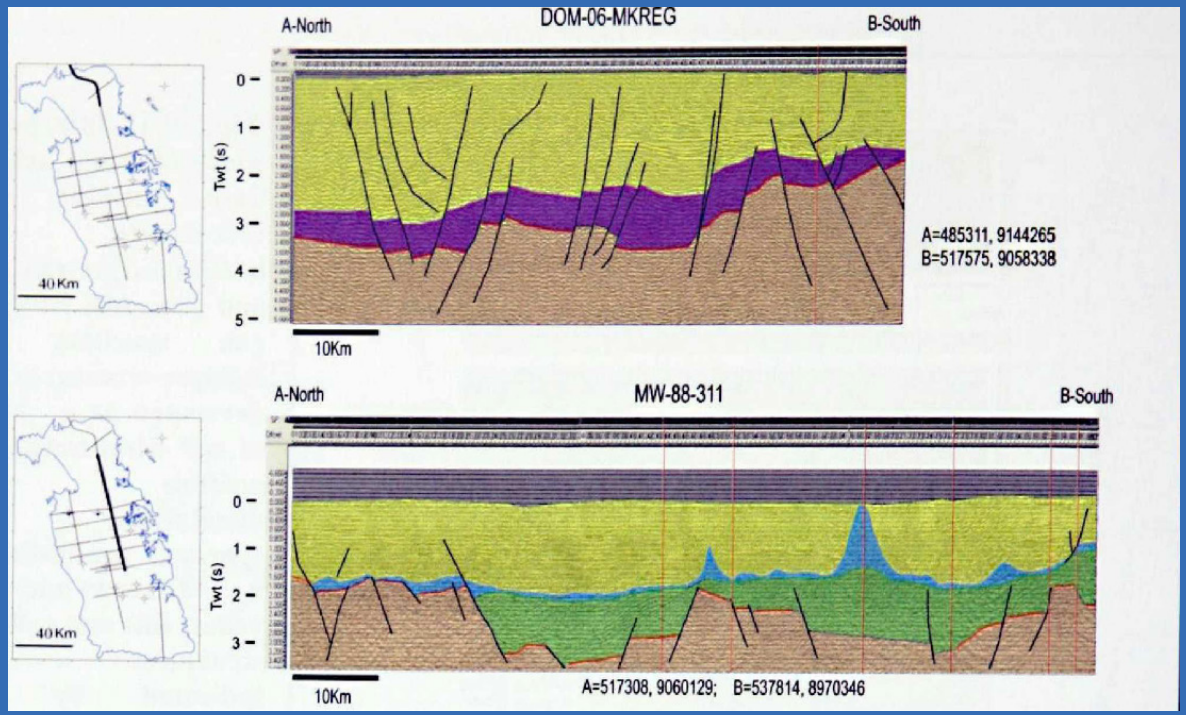
AGE		UNIT	THICKNESS	LITHOFACIES	PALAEONTOLOGY
LOWER JURASSIC	Liassic	MANDANGA FORMATION	300 m	Braided stream deposits; Conglomeratic and very coarse grained, arcosic, friable, buff coloured sandstones	Fossil woods Macroflora 304
				major unconformity	
		MADABA FORMATION	300 m	red beds: Meandering river deposits; Fining-upward cycles of multicoloured sandstones, siltstones and mudstones	Classopollis chateaunovi Microflora Sauropod remains Macroflora 96
UPPER TRIASSIC	Rhaetian	MKUJU FORMATION	200 m	red beds: Braided stream deposits; mainly coarse grained, white, feldspathic, partly calcareous sandstones with intercalations of red siltstones	Polypodiisporites ipsviciensis Microflora Macroflora 147
	Norian	MBARANGANDU FORMATION	250 m	Braided stream deposits; Laterally not persistent cycles of mainly medium and coarse grained, grey, yellow and greenish sandstones with calcareous concretions	Indeterminable plant fragments
		LUWEGU FORMATION	200 m	red beds: Fluviolacustrine flood plain deposits; mainly red siltstones with thin interbedded, white and greenish, fine grained, flaserbedded sandstones	Minutosaccus crenulatus Microflora Samaropollenites speciosus Microflora
	Carnian	MAHOGO FORMATION	300 m	Braided stream deposits; Laterally not persistent cycles of mainly medium and coarse grained, yellow and greenish grey sandstones with a characteristic spotted appearance; rare intercalations of siltstones	Staurosaccites quadrifidus Microflora Macroflora 75 Macroflora 74
MIDDLE TRIASSIC	Ladinian	LUHOMBERO FORMATION	1400 m	Braided stream deposits; Laterally not persistent cycles of mainly medium and coarse grained, grey and yellow sandstones; thin intercalations of siltstones and mudstones	Dinosauroid track
	Anisian				
LOWER TRIASSIC	Scythian	RUFIJI FORMATION	2100 m	Braided stream deposits; Laterally persistent cycles of mainly medium and coarse grained, grey and greenish grey sandstones with intercalations of siltstones and mudstones	Macroflora 132 Macroflora 84
UPPER PERMIAN		HATAMBULO FORMATION	900 m	Deltaic-lacustrine deposits: Ruaha Member: fluviodeltaic sandstones Sumbadzi Member: lacustrine black shales Pangani Member: deltaic, coarse sandstones Kidani Member: fluviodeltaic sandstones	Guttulapollenites hannonicus Microflora Macroflora 218 Reptile remain

Tab. 1. Stratigraphic table of the Karoo Sequence of the Luwegu Basin

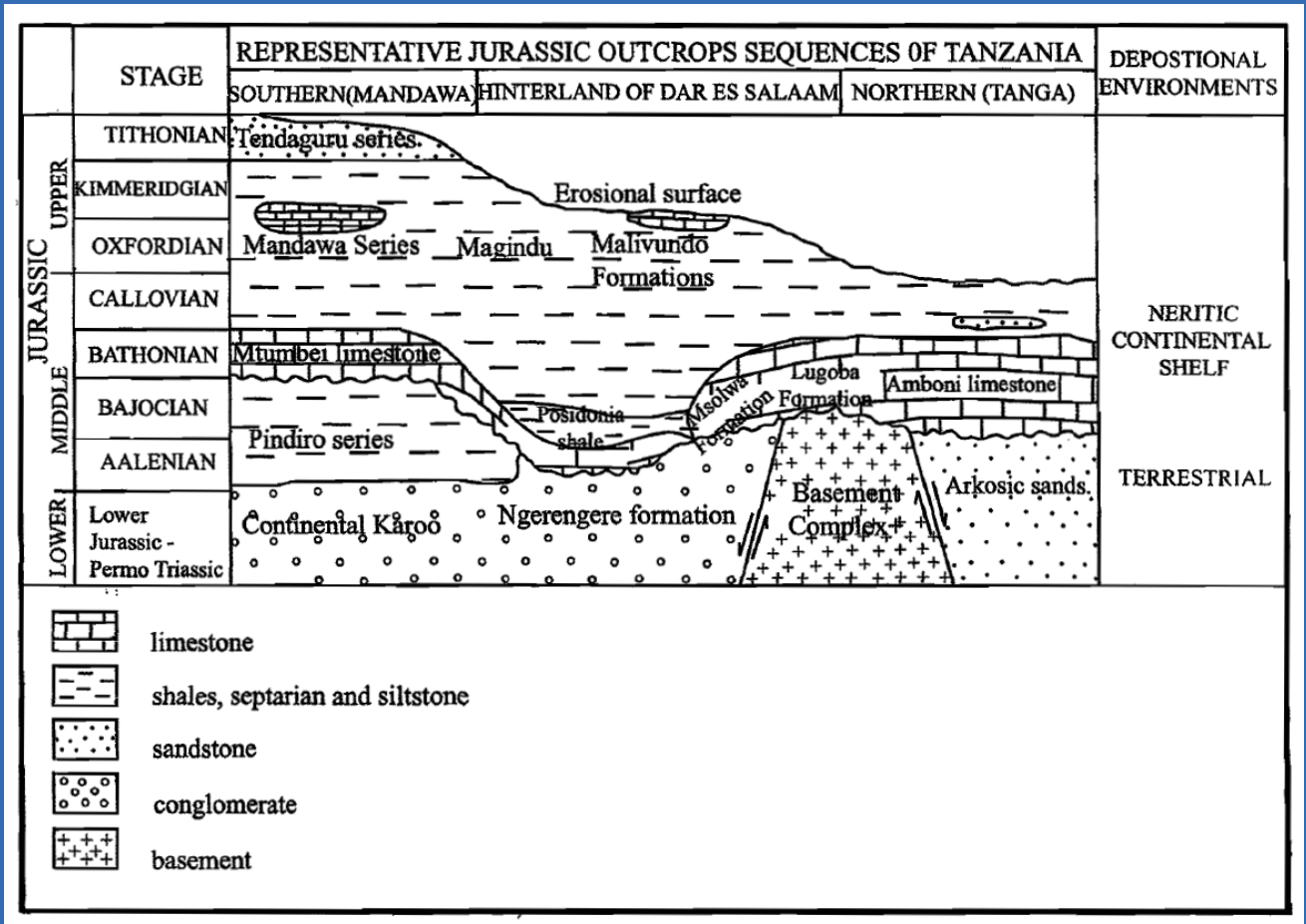
Hankel, O. (1987). Lithostratigraphic subdivision of the Karoo rocks of the Luwegu Basin (Tanzania). *Geologische Rundschau*, *76*(2), 539-565

Plus industry reports and legacy databases





Local syntheses



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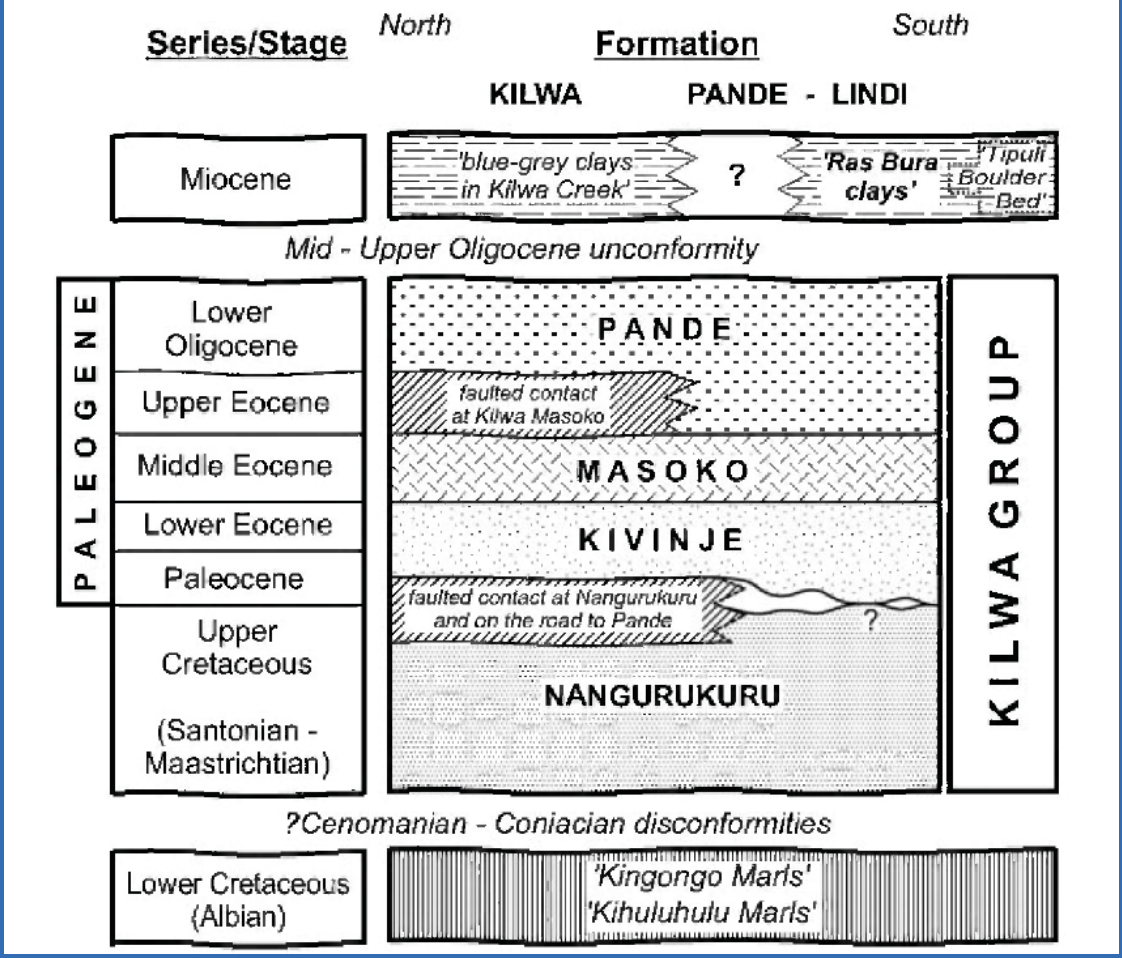
Recent academic work



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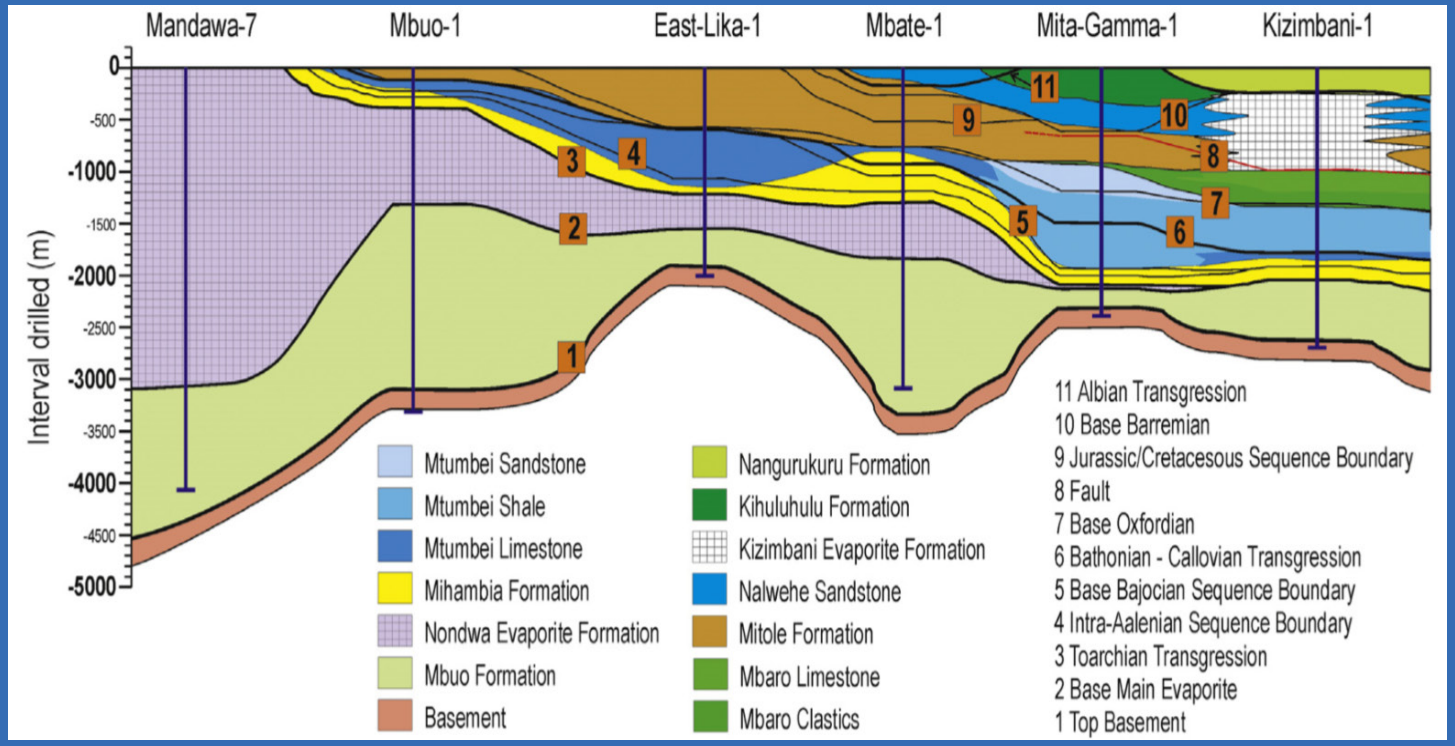
More recent academic work



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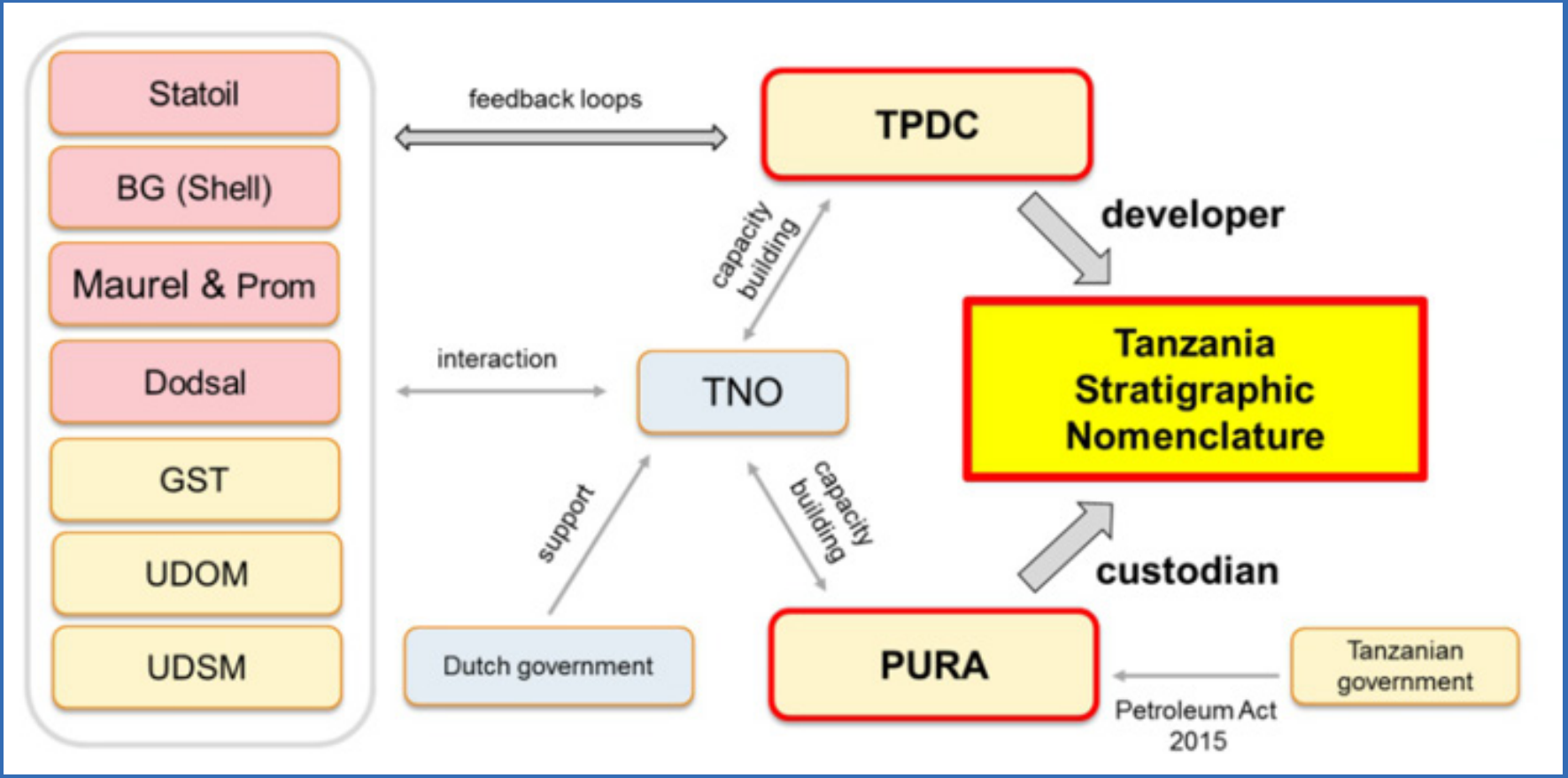
New fieldwork to fill critical gaps

Dr. Cassy Mtlela pers. comm. (UDSM) & Noortje Versteijlen MSc-thesis (UU)

Linking the on- and offshore

- Recent exploration studies from BG (Shell) and Statoil (Equinor) have resulted in a robust stratigraphic framework for the offshore with a strong imprint from seismic data
- In the onshore Mandawa Basin an international drilling program (TDP) has provided a comprehensive dataset and lithostratigraphic subdivision with a strong imprint from lithological, sedimentological, and bio- and chemostratigraphic data
- The challenge lies in molding all units into one overarching and comprehensive scheme

Complex stakeholder interactions



Project overview and deliverables

Tanzania Stratigraphic Nomenclature Project

WORK PACKAGES

WP Structural Framework
- ⇨ Structural elements definition
- ⇨ Tectonic evolution

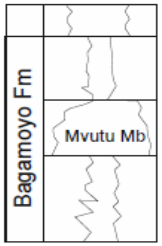
WP Lithology
- ⇨ Lithological description & classification
- ☐ [Outcrop, cores, well logs]
- ⇨ Interpretations
- ☐ [Depositional environment]
- ☐ [Boundaries]

WP Biostratigraphy
- ⇨ Age relationships
- ☐ [Compilation, New analyses]
- ⇨ Interpretation
- ☐ [Depositional environment,
- ☐ ☐ sequence stratigraphy]

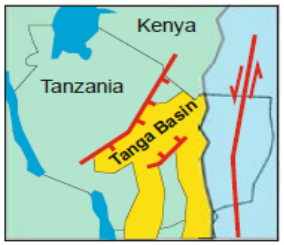
END-PRODUCT

Bagamoyo Formation
- ⇨ Definition [short description]
- ⇨ Name derivation
- ⇨ Stratotype
- ⇨ Hierarchy [Chamba Gp; Mvutu Mb]
- ⇨ Description [mudstones, sandstones]
- ⇨ Age [Late Aptian]
- ⇨ Depositional environment
- ⇨ Bounaries [eroded top]
- ⇨ Distribution [Tanga Basin]

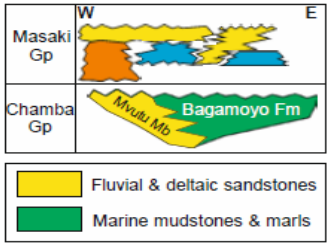
STRATOTYPE



STRUCTURAL ELEMENTS



WHEELER DIAGRAM



SKILLS

- ⇨ Data management [archiving]
- ⇨ Scientific writing [presentation]
- ⇨ Cooperation [round table sessions]
- ⇨ Decision making
- ⇨ Organisation

PITFALLS

- ⇨ Uncertainties [poor age constraints; lack of data]
- ⇨ Diachronism
- ⇨ Historical context [established names]
- ⇨ Regional perspective [detail versus overview]
- ⇨ Accessibility [web-based, book, publication]
- ⇨ Gained insights and updates

Capacity building workshops and round table sessions

- Various workshops on stratigraphy, structural geology and scientific writing have been held
- For decision making on stratigraphic hierarchy, formation names, bounding surfaces, etc. round table sessions have been organized
- All relevant stakeholders are invited to join these sessions

Communication and dissemination are key

- For the day-to-day activities communication between the stakeholders and TNO has been maintained through regular contact
- For publicity and information sharing, quarterly newsletters have been published and sent to all stakeholders
- Publicity and dissemination of results are also to be accomplished via conference presentations
- Upon completion of the TSNP, a publication in "*Journal of African Earth Sciences*" is foreseen

Take-home message

- Supporting national/governmental organizations to develop and maintain subsurface data management and an applicable “geological language” (e.g. a nomenclature)

- Capacity enhancement in all aspects related to the subsurface is a key element

- In combination, this will contribute to good governance of the subsurface energy sector and will maximize long-term returns from national subsurface resources

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Thank you for your attention!

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