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Digital Stratigraphic Lexicon of the Krishna-Godavari Basin, India

D. S. N. Raju[1], Mamallapalli O'Neil[2,*], A. Nallapa Reddy[1]

[1]*Formerly @Oil and Natural Gas Corporation Ltd.*
[2]*International Union of Geological Sciences Deep-Time Digital Earth, D.No: 15-4-2/28, Luthergiri, Rajahmundry, Andhra Pradesh 533105, India*

ABSTRACT

This study presents the development of a stratigraphic vocabulary, known as the Indian Plate Lexicon (IndpLEX), specifically focusing on the Krishna-Godavari Basin. The authors compiled the existing published stratigraphic data and organized it in a standard format created by Geologic Time Scale (GTS). The stratigraphic data of the Krishna-Godavari Basin was critically reviewed by following the Code of Stratigraphic Nomenclature of India and the International Stratigraphic Guide to ensure that stratigraphic nomenclature is accurately and consistently used, promoting effective communication and coordination. The litho-formations are separated and listed in chronological order, from the youngest to the oldest, according to their ages. When assessing sedimentary facies in relation to different geological events and searching for mineral and fossil fuel reserves, exploration geologists may find this terminology to be a supportive resource. The IndpLEX aims to provide stratigraphers in India with a comprehensive resource for developing new formations, modifying the existing ones, and offering a standard code or guide.

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1. INTRODUCTION

Several countries have on-line collections of the nomenclature for their geologic formations, including generalised descriptions of lithology, the type of stratal boundaries (upper and lower contacts), the location (outcrop or well section) in which they are found, and other information. Examples from the Americas include U.S. Geologic Names Lexicon (GEOLEX) at the US Geological Survey, Lexicon of Canadian Geological Names on-line (WEBLEX) at the Canadian Geological Survey, etc. Examples from Europe include the Norwegian Interactive Offshore Stratigraphic lexicon (NORLEX) of Norway and the BGS Lexicon at the British Geological Survey. These geological lexicons have a wide range of user interfaces. However, some nations only have physical books documenting their geologic formations. (e.g., Vietnam, China, Malaysia, and the compilation by Dr. D.S.N. Raju et al., (2018); Raju and Misra (2009) in the Oil and Natural Gas Corporation Bulletin for the Indian Plate regions).

The Geologic Time Scale (GTS), initiative led by Prof. James Ogg and others (Ogg et al., 2023), aims to create a digital stratigraphic lexicon for a number of nations, including India, China, Vietnam, Thailand, and Malaysia. Prof James Ogg invited Dr. DSN Raju of Oil and Natural Gas Corporation to collaborate with them on their initiative to digitise the Indian stratigraphic lexicon after reading his book on the Phanerozoic Stratigraphy of India. Dr. DSN Raju and other authors collaborated with the GTS initiative to digitize the Indian stratigraphic lexicon, and the IndpLEX was created as a result.

GSI and university experts stepped forward to provide data for the IndpLEX for various sedimentary basins. The IndpLEX is currently accessible at both the Geological Society of India, Bangalore's website and `indplex.geolex.org/index.php` (part of the geolex.org suite for Asia). The existing strati-

*Corresponding author. Email: oneil.rhylet@gmail.com (MO), anreddy54@gmail.com (ANR)

graphic data was reviewed critically for appropriate stratigraphic terminology, and the rules of procedure for effective communication, coordination and understanding. The nomenclature of the stratigraphic units was updated by following the Code of Stratigraphic Nomenclature of India (1977) and the International Stratigraphic Guide (Murphy and Salvador, 1994). The present report includes only the stratigraphic database of the Krishna-Godavari Basin, and provides a concise explanation of the stratigraphic lexicon (IndpLEX) for the benefit of geology students, researchers, and academicians.

2. METHODOLOGY

The gathering and refining of the source data is the most important component of an authoritative database. D.S.N. Raju and his team diligently compiled data for every single geological formation for the IndpLEX. The resultant comprehensive formation-by-formation descriptions of different basins of the Indian Plate were provided by many contributors as Microsoft Word documents in a standard format for publication. The online lexicons employ the MySQL database management system to archive information from uploaded .doc files and facilitate the retrieval of data for instant webpages.

3. THE DEVELOPMENT OF AN INDIAN PLATE-SPECIFIC ONLINE DICTIONARY

The Paleogeography Working Group of the International Union of Geological Sciences (IUGS) programme for Deep-Time Digital Earth (DDE) has two objectives: (1) to link online national lexicons for all the volcanic and sedimentary formations, and to create online lexicons for nations that do not yet have these; and (2) to focus on particular regions and time periods for testing and showcasing the paleogeographic output from the combination of these databases. In order to achieve these objectives, the Geologic Time Scale Foundation in collaboration with computer engineering students at Purdue University (Indiana, USA) and local specialists in East Asiadeveloped novel cloud-based lexicons and applied interactive visualization techniques to particular regions. At the same time, Dr. D.S.N. Raju organized a giant collaboration of renowned stratigraphic experts from several countries-India, Pakistan, Bangladesh and so on in order to create a considerably updated and improvised summary of all the onshore and offshore lithologic units of the Indian Plate.

D.S.N. Raju oversaw the compilation of the Indian Plate Lexicon by expert teams with coordinators for each major basin region: Pakistan (Nusrat K. Siddiqui), Himalaya (O.N. Bhargava, Birendra Singh), Karakoram (K.P. Juyal), Kashmir (Rajeev Patnaik), Gondwana basins (G.V.R. Prasad and Varun Parmar), NE India (Kapesa Lokho), Krishna-Godavari and Cauvery (A. Nallapa Reddy, R. Nagendrawith D.S.N. Raju's team (O'Neil Mamallapalli and A. Nallapa Reddy) covering most of the other basins from the Oil and Natural Gas Corporationstudies. The KG Basin's stratigraphic database was summarised and compiled in an interactive standard digital format by the present authors.

4. GEOLOGICAL HISTORY, STRATIGRAPHIC SETTING AND HYDROCARBON POTENTIAL

The Krishna-Godavari Basin is an example of a passive margin basin and its evolution has been polycyclic (dual-rift province). With comparable outcrops in the northwest, it contains a diverse range of sedimentary facies from the Early Permian through the Cenozoic. The basin's extensive tectonic expression includes a linear horst-graben system, growth fault/rollover, block tilting along a synthetic fault over the intra-shelf regime, and toe thrust, displaying a typical passive margin manifestation (Venkatarengan et al., 1993; Rao, 2001).

During the early Jurassic, the supercontinent Gondwanaland contained the massive intracratonic rift basin known as the Krishna-Godavari Basin. Gondwanaland began to disintegrate during the late Jurassic-early Cretaceous giving birth to a number of basins along the east coast of India including the K-G Basin. The character of K-G basin transformed from intracratonic to pericratonic basin (Rao, 2001). Beyond the Cretaceous, the basin (being a part of Indian plate) started to move northward, as a consequence of tectonic interactions of different plates, from its former position (˜50^0S). The eastern continental plate margin of the Basin rotated anticlockwise along with the northward movement. It began in an east-west orientation, rotated roughly 20^0 anticlockwise, and is now trending in a NNE-SSW trajectory. The congruence of Masulipatnam and the tri-junction of the dismemberment within basin align as a result of ge-

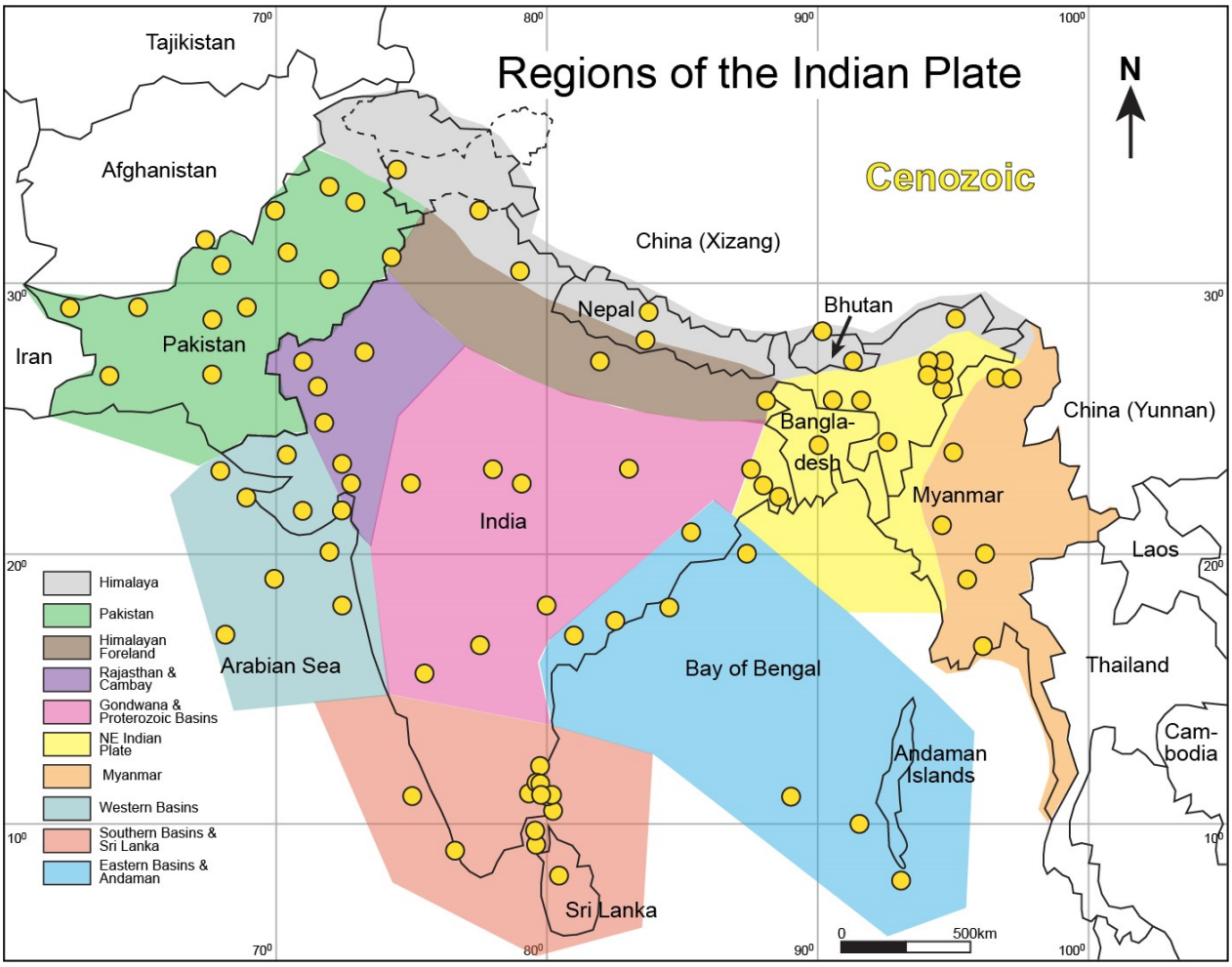


Fig. 1. Overview of IndpLEX Database homepage with a clickable map – displays detailed information on any province highlighted with yellow dots *(from http://indplex.geolex.org/index.php)*.

ological processes occurring in the region. The older Gondwana graben (i.e. Pranhita-Godavari) is lying underneath the KG Basin, The Pranhita-Godavari graben stretches from NE to SW up to the OCB (Oceanic crustal boundary). The described geological history reveals that the basin had a complex tectonic evolution involving rifting, plate movements, rotation, and the development of graben structures.

The stratigraphic succession in the Krishna-Godavari Basin spans in age from the Permian to the Holocene. The Chintalapudi sandstone of the Permian is overlain by the older Talchir Formation of the Permo-Carboniferous, which is in turn overlain by Barakar Formation. These pre-Cretaceous fluvial deposits are separated from the deltaic-marine Cretaceous units, and younger parts by a reddish-colored sandstone series. The Mesozoics and Cenozoic sediments in the basin are distinguished lithologically by the Late Cretaceous-Early Palaeocene basalts. The middle Eocene's substantial carbonate portion further distinguishes the stratigraphic column. The proximal arenaceous and basinal argillaceous sequences, which are the litho-facies variations of a specific geological epoch, are easily distinguishable in the basin. A comprehensive rock stratigraphic nomenclature was proposed and is being followed in this study.

The presence of acritarchs in the Draksharama Argillite reveals that the first marine transgression occurred during the Early Permian (Asselian-Sakmarian). The succession of formations, their gross lithology, and thickness are given in Megachart-I, and the paleoenvironments of deposition are shown in Megachart II (Raju, 2017). Mega charts I and II are freely accessible on the internet.

The habitat of hydrocarbons in the KG basin is distributed geographically from land to the ultra-deep sea domain and spans a broad stratigraphic spectrum from the Permian to Pliocene (Raju et al., 2021). The major plays identified are the Permian (Kommugudem Fm.), Permo-Triassic (Man-

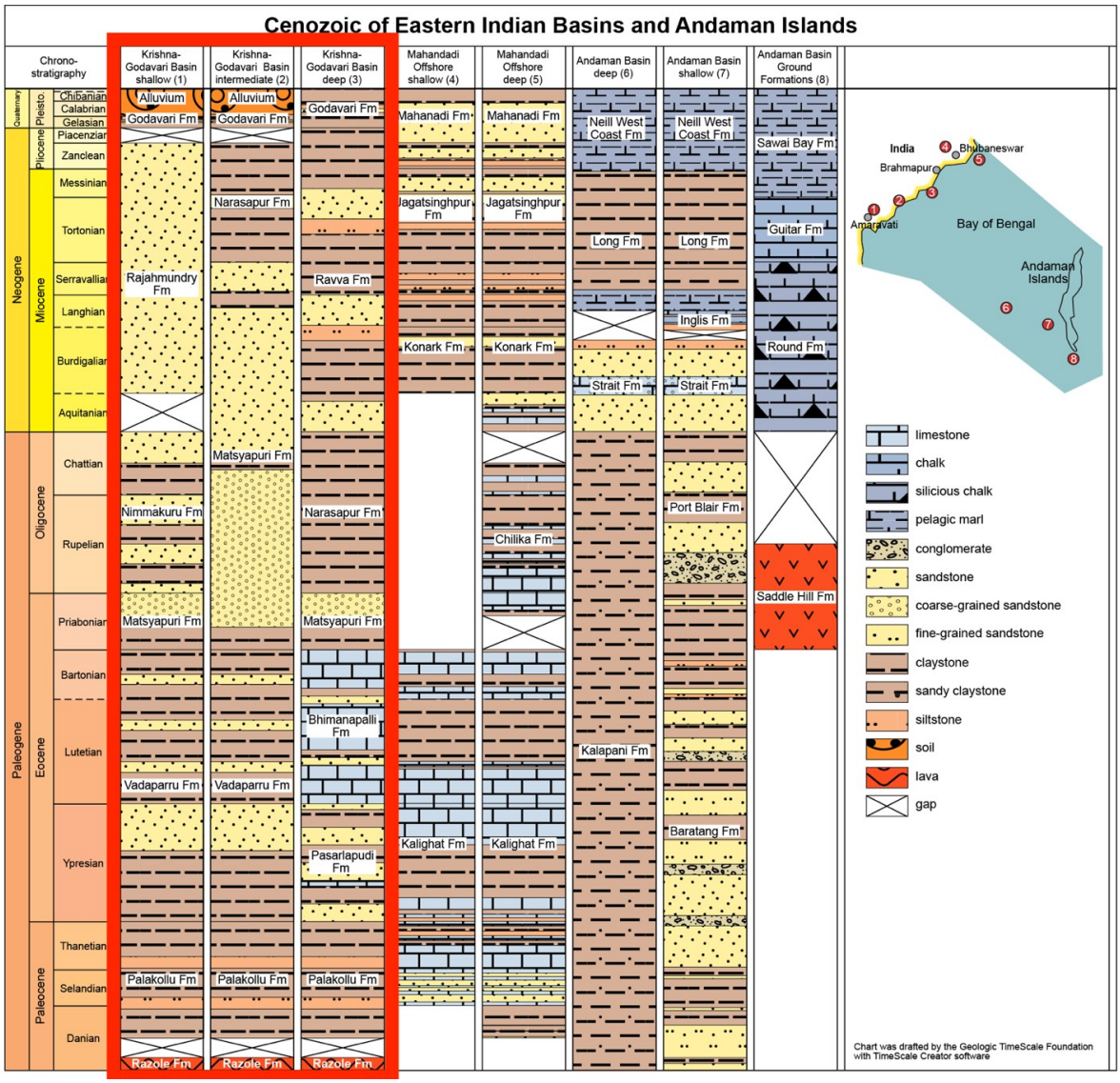


Fig. 2. Lithology patterns of Krishna-Godavari Basin (highlighted in red box) showing correlations with Eastern Indian Basins and Andaman Islands *(from http://indplex.geolex.org/index.php)*.

dapeta Fm.), Late Jurassic-Aptian (Gollapalli Fm.), Albian-Turonian (Nandigama/Kanukollu Fm.), Aptian-Albian (Raghavapuram Fm.), Late Albian-Turonian (Vanadurru Fm.), Late Paleocene (Pasarlapudi/Vaparru Fm.), Oligocene-Miocene ((Matsyapuri/ Ravva Fm.), and Pliocene (Godavari Fm.).

5. SUMMARY OF THE RESULTS

The resulting stratigraphic lexiconof the KG Basin is currently housed at indplex.geolex.org/index.php and includes pages on each of 28geologic formations. This Lexicon database, the collection of map/strat-column user graphic interfaces, and the software that enables one-click connecting to pyGPlates and pyGMT. Thereby, this database is intended to be accessible to relevant regional organizations for continuous improvement and upkeep.The Geological Society of India in Bangalore hosts this lexicon, and isfreely accessible on their website. This choice was made to encourage geologists,academicians and students in the India to use it.

The IndpLEX is connected to the Vietnam, Thailand, and China Lexicon websites, allowing users to search for any formation in Asia and plot it onto plate reconstructions. For instance, one can look for any Cretaceous-aged formations having hydrocarbons in their lithologies and map such formations on a model of the Cretaceous plate.

A graphic overview of the stratigraphic database of the Krishna-Godavari Basin is illustrated in Fig. 1–5.

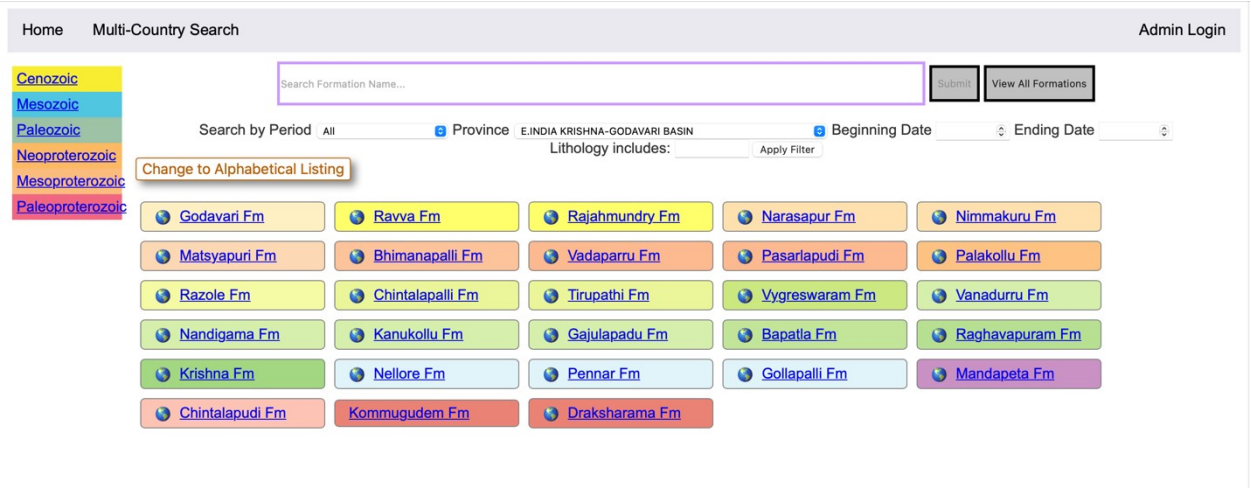


Fig. 3. Display of Krishna-Godavari Basin geologic formations with dedicated user-interfaces *(from http://indplex.geolex.org/index.php)*.

Ravva Fm

Period: Neogene
Age Interval: Early-Middle Miocene

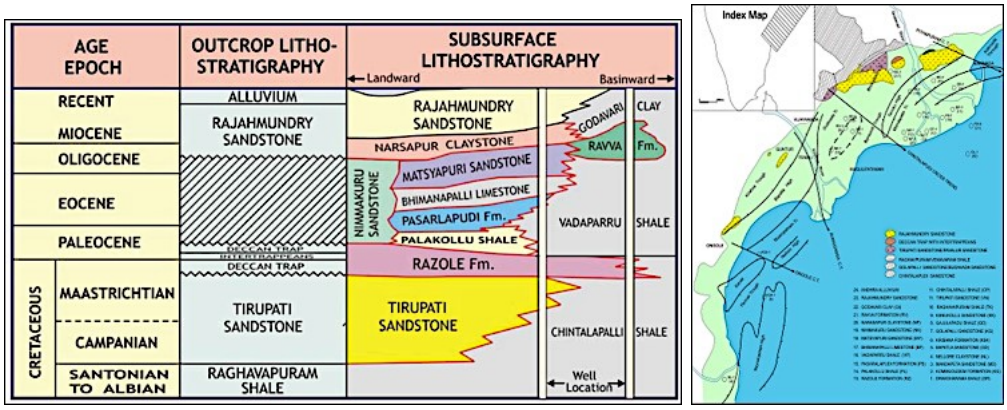
Province: E.India Krishna-Godavari Basin

Type Locality and Naming

BASINAL: The type section is in the Well Ravva-D (depth interval: 1780-2870 m). The hypostratotype is in the Well G-A-A (depth interval: 2110-2900 m). It was named after Ravva by ONGC team steered by Venkatarengan et al. (1993) adopted and issued as Document-VII by KDMIPE, ONGC, Dehradun (1993). **[Original Publication:** Rao, G.N. (1990) Subsurface stratigraphic nomenclature of Krishna-Godavari Basin, ONGC, unpublished report.]. **Reference well:** Well G-1-1, Interval 2110-2900 m and thickness is 790 m.

[Figure: Generalized Late Cretaceous-Cenozoic lithostratigraphy transect, Krishna-Godavari Basin. *From Keller et al., 2011, Jour. Geol. Soc. India, 78:399-428, their Fig. 2]*

[Figure: Map showing the locations of designated holostratotype section for the formation in the KG Basin (After ONGC, Pandey and Dave, 1998) *in Raju et al., 2021, ONGC Bulletin, Special Issue, Vol. 56, No. 2]*

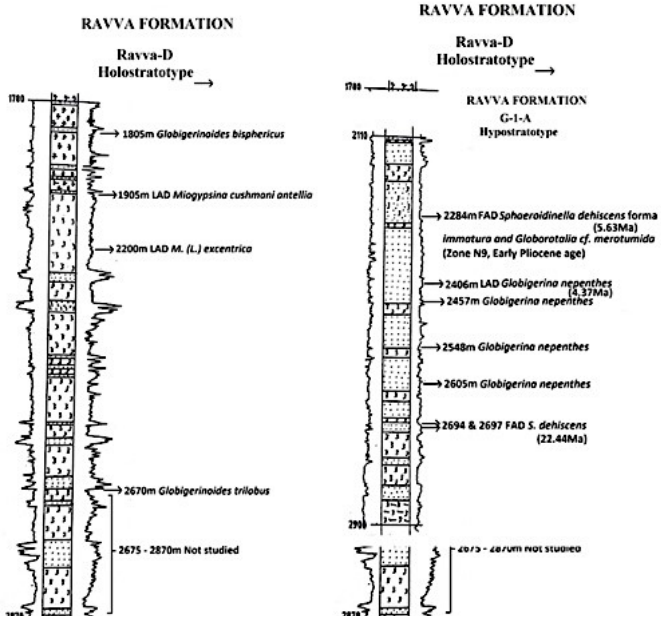


Lithology and Thickness

Clayey sandstone. In the type section (well in Ravva-D), the formation consists of thin sandstone beds alternating with thick clay beds and minor siltstone layers. The sandstone in the section is argillaceous sometimes pebbly, ill sorted. At the contact with the claystone, the sand is mostly glauconitic and calcareous, associated claystone is mostly pyritiferous, sometimes silty, calcareous, with slight fissility. In the reference section (well G-A-A), it is sandstone and claystone alternation. The sandstone is grey to dark grey, fine to medium grained. The claystone is dark grey, moderately hard, compact and at places with pyrite. At places claystone is silty. It has a thickness varying from 790-990m.

[Figure 1: Well log of Ravva-D Holostratotype (modified after Venkatarengan et al., 1993)]

[Figure 2: Well log of G-1-A Hypostratotype (modified after Venkatarengan et al., 1993)]



Relationships and Distribution

Lower contact

Conformable with Narasapur Fm Claystone. Or Unconformable with the Matsyapuri Fm Sandstone.

Upper contact

Unconformable with the Godavari Fm.

Regional extent

It is extensively developed in parts of Krishna-Godavari Basin. Partly coeval with Rajahmundry Fm (which is more landward).

GeoJSON

{"type":"Feature","geometry":{"type":"MultiPolygon","coordinates":[[[[84.66,19.11],[81.3,17.11],[81.06,16.77],[80.48,16.38],[80.16,15.76],[80,15.18],[80,14.09],[80.68,14.09],[80.76,15.07],[81.22,15.76],[82.64,16.55],[83.13,17.06],[85.03,18.67],[84.66,19.11]]]]}}

Fossils

Foraminifera – *Globigerinoides sicanus, Gs. trilobus, Gs. primordius, Praeorbulina transitoria, P. glomerosa, Globorotalia periphorororonda, Gr. siakensis, Globoquadrina altispira altispira, Gq. altispira globosa, Miogypsina (L) excentrica, Lenticulina, Uvigerina (costate)*. Ichnofossils – *Skolithos, Ophiomorpha, Thalassinoides, Planolites and Paleophycus.*

Age

Early-Middle Miocene

Age Span:

Beginning stage: Aquitanian
Fraction up in beginning stage: 0.0
Beginning date (Ma): 23.04
Ending stage: Zanclean
Fraction up in the ending stage: 1.0
Ending date (Ma): 3.60

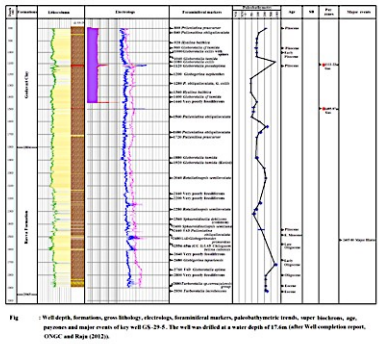
Depositional setting

Inner-Middle neritic.

Depositional pattern:

Additional Information

[Figure 3: Lithocolumn, well logs, foraminiferal datums and paleobathymetry of Ravva Fm in well GS-29-5 showing lateral variation (after well completion report, ONGC and Raju (2013)]



Compiler:

D.S.N Raju and A. Nallapa Reddy

Fig. 4. Lexicon Format of selected '*Ravva Fm*' with type locality, lithology, upper/lower contacts and regional extent *(from http://indplex.geolex.org/index.php)*.

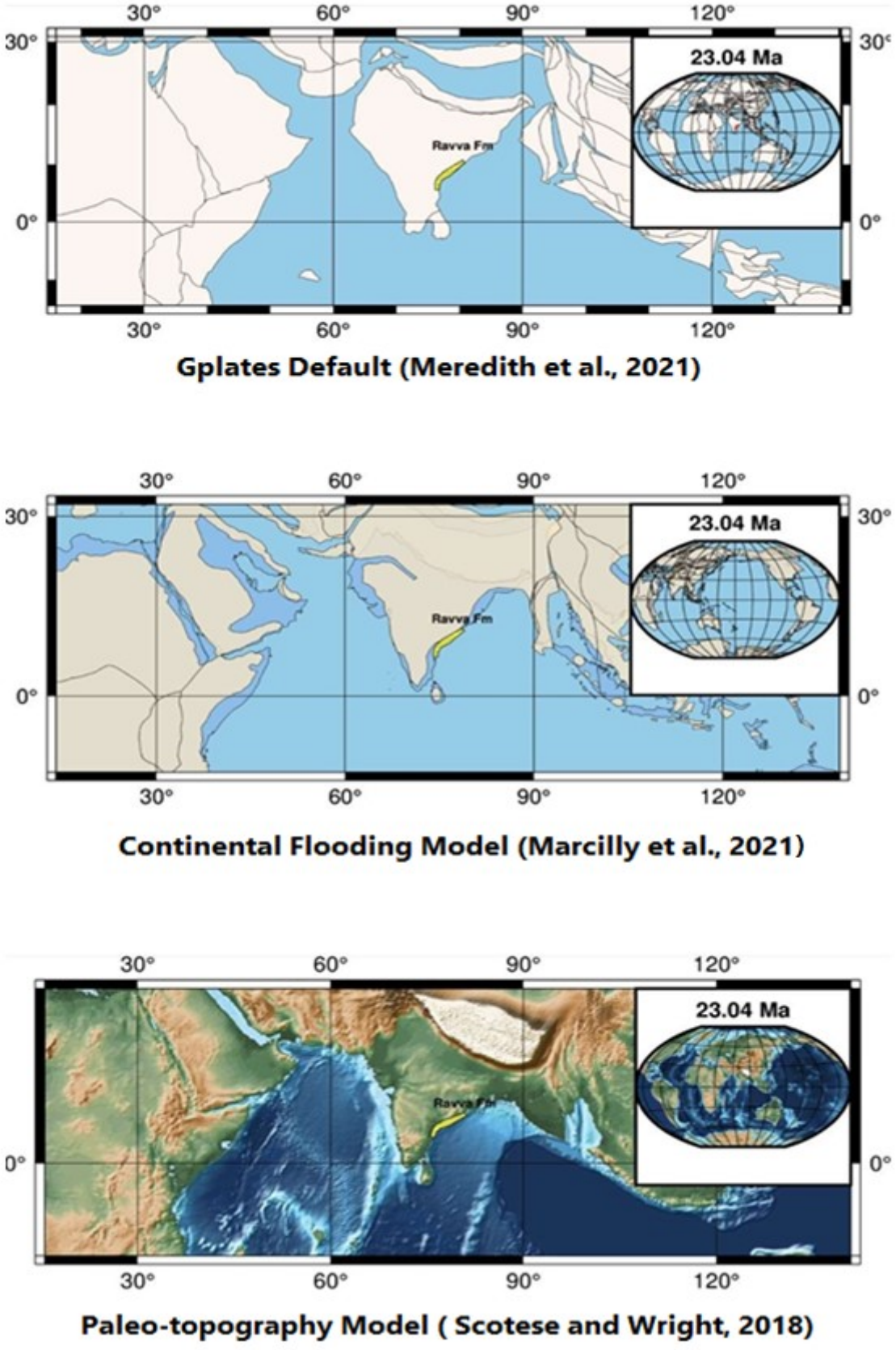


Fig. 5. Three Plate Reconstructions Models for the Ravva Fm at 23.04 Ma *(from http://indplex.geolex.org/index.php)*. (References: Merdith et al., 2021; Marcilly et al., 2021; Scotese and Wright, 2018)

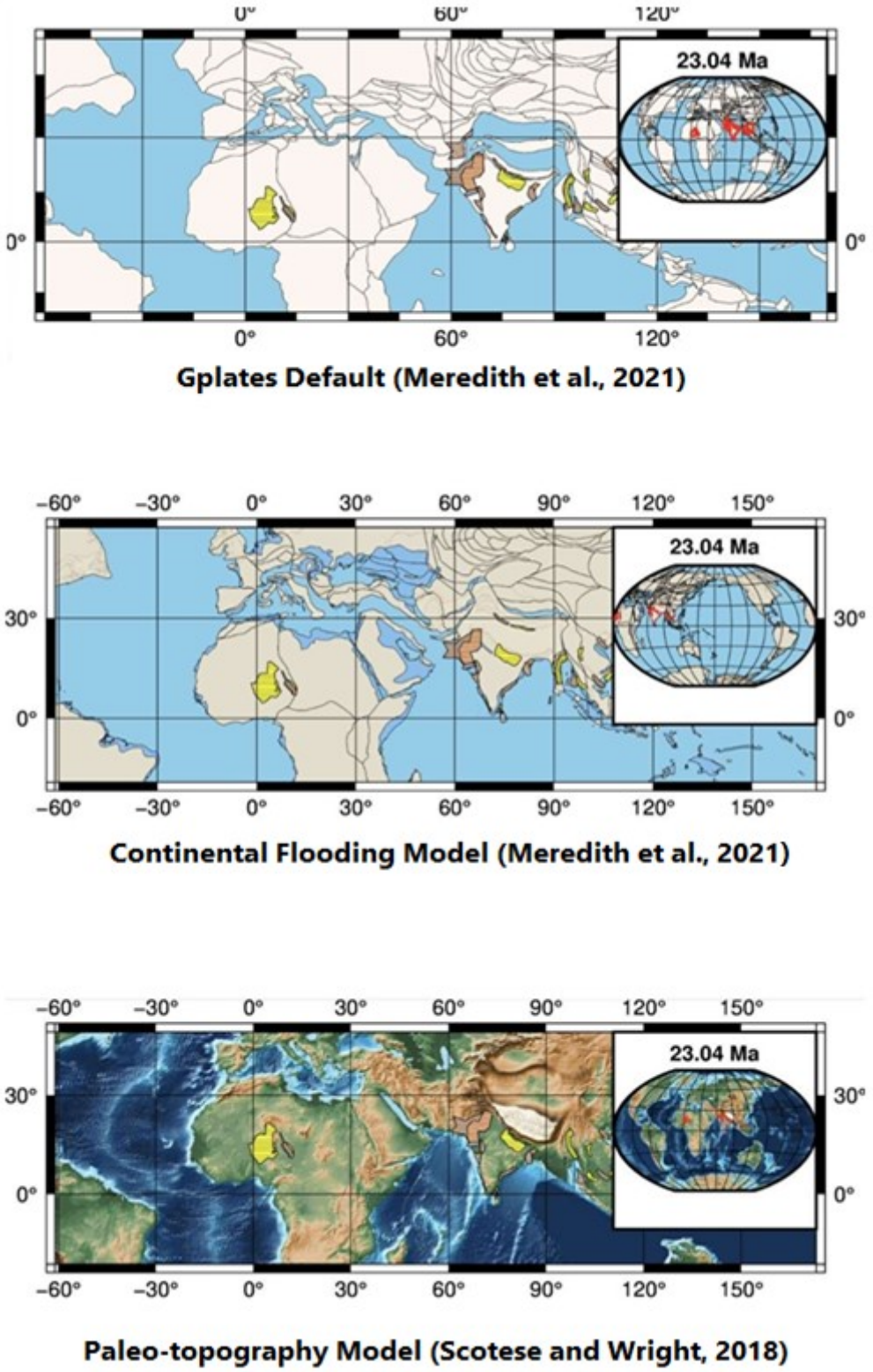


Fig. 6. Multi-Country Search Plate Models for the Ravva Fm. at 23.04 Ma *(from http://indplex.geolex.org/index.php)*. (References: Merdith et al., 2021; Scotese and Wright, 2018)

6. CONCLUSIONS

- A stratigraphic lexicon is created for the first time, as a valuable resource for stratigraphers and exploration geologists working in the Krishna-Godavari Basin, providing standard terminology and facilitating the assessment of sedimentary facies and exploration for mineral and hydrocarbon reserves.
- The current study forms part of the major compilation on Indian Plate Stratigraphic Lexicon (IndPLEX) initiated by the Geologic Time Scale (GTS).
- This lexicon contains stratigraphic information for 28 geologic formations, and the databse is stored in a map/strat-column user graphic interfaces, and the software that enables one-click connecting to pyGPlates and pyGMT.
- The digital lexicon of the Krishna-Godavari Basin is currently accessible at both the Geological Society of India, Bangalore's website and indplex.geolex.org/index.php(part of the geolex.org suite for Asia).

CONFLICT OF INTEREST

On behalf of all authors, the corresponding author states that there is no conflict of interest.

NOTE

This is a posthumous publication by D. S. N. Raju.

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