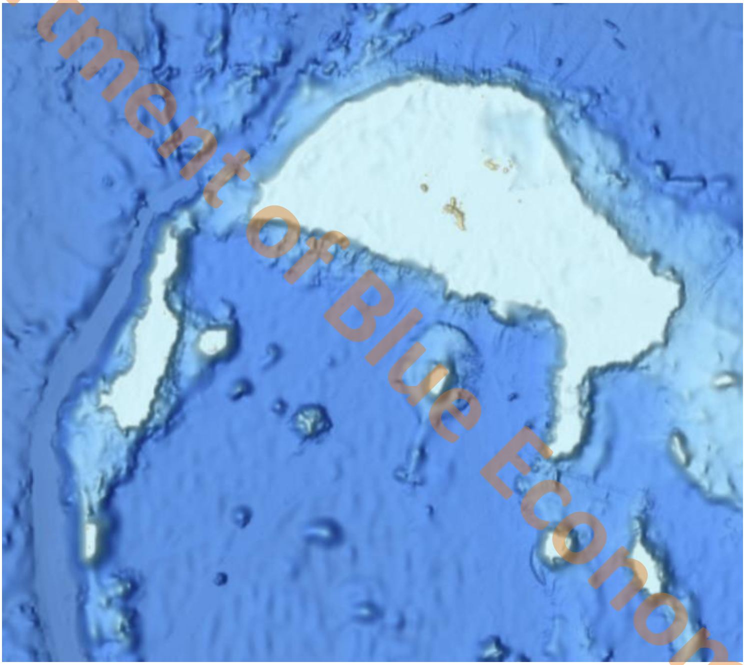
The Seychelles Micro-Continent



SEYCHELLES BLUE ECONOMY

ORGANISATION INTERNATIONALE DE la francophonie


Bougainville
Anse Royale

The
Seychelles
Micro-Continent

Title: *The Seychelles Micro-continent - English E-BOOK*

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ISBN: 978-99995-981-4-9

First Edition, December 2024

Self-published by the author.

Printed in the Seychelles, by *“Printhouse Seychelles”*

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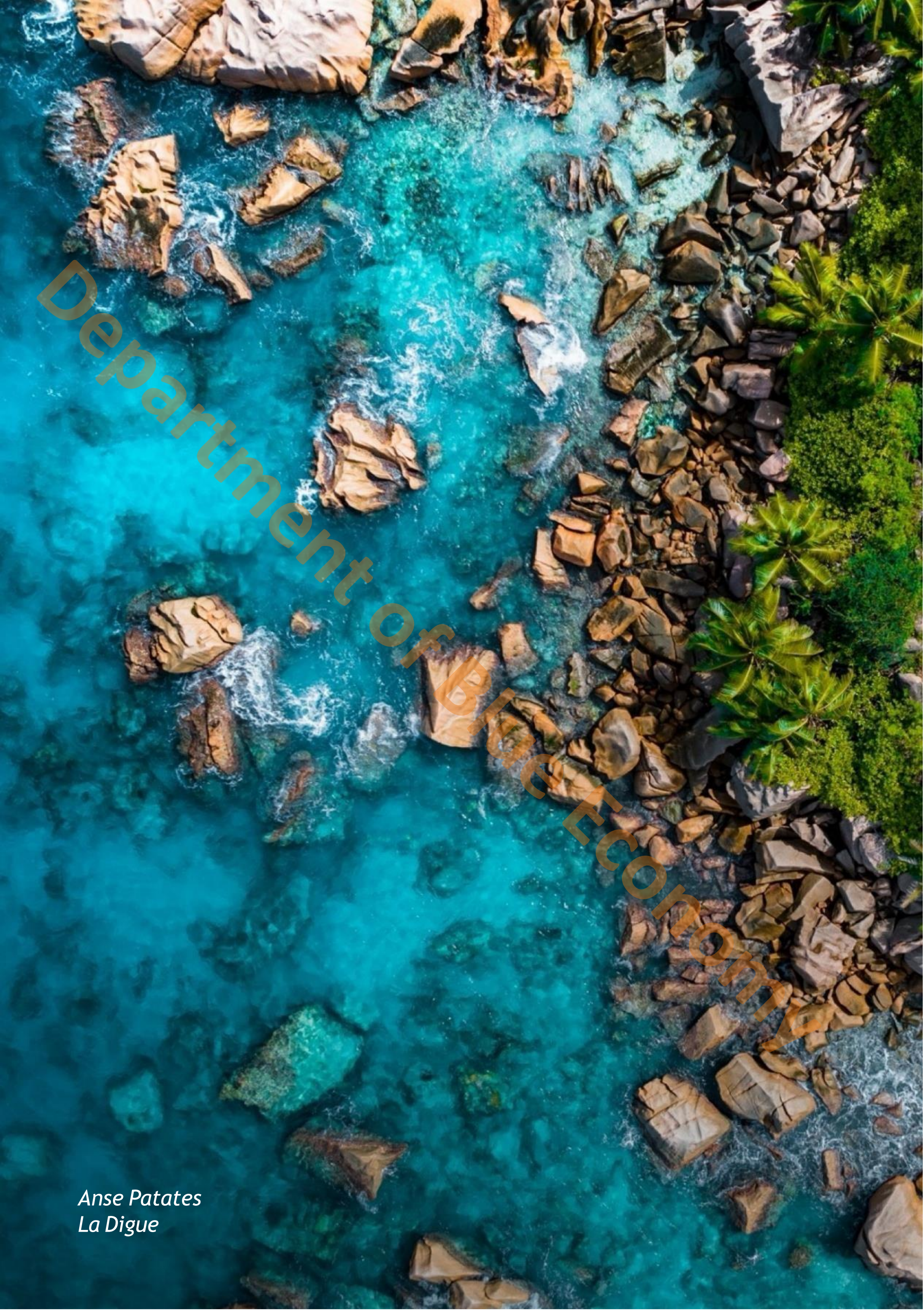
Preface

The Seychelles archipelago, often admired for its pristine natural beauty in isolation, holds within its granite foundation, the secret of a geological journey spanning over 750 million years ago. This book, *The Seychelles Micro-Continent*, was born out of a desire to uncover and articulate the intricate geological history of these islands, from their origins deep within an ancient supercontinent, through various tectonic rifts and drifts, to their present state of isolation as a micro-continent in the Western Indian Ocean. The project began as an exploration of the unique geological makeup of Seychelles, and the main processes that have shaped the islands and their ecosystems until the human inhabitants arrived. Through this work, I aim to present the complex interactions between continents that have led to the Seychelles as we know them today, bridging the gap between raw geological data and the larger narrative of our planet's ever-changing surface.

My hope is that this book will serve as both an educational tool and a celebration of the geological heritage of the Seychelles. It is written not only for fellow geologists but for anyone intrigued by the wonders of natural history of the Seychelles. This book will take you on a journey through time, one that I believe holds profound significance for understanding the natural forces that continue to shape our world. The book's completion has been as challenging as it has been rewarding, and I am grateful for the support of colleagues, mentors, and institutions that made it possible. Special acknowledgments and thanks to Organisation internationale de la Francophonie (OIF), the sponsor of the project ; The Seychelles Blue Economy department, Commissioner of the project ; Mr Stefano Colombo, with Drone Training ; Ms. Gabriella Gonthier, with the administrative works ; PetroSeychelles, for allowing access to the geological database of Seychelles; Peer editors Mr Gideon Brunsdon, Mrs Dawn Francis and Mr. Robert Ahweng ; Mentors Prof. Maarten De Wit, Mr. Callum Anderson, Mr Patrick Samson and Mr Patrick Joseph ; again many thanks for making this book a reality.

Jean-Luc A. Mondon



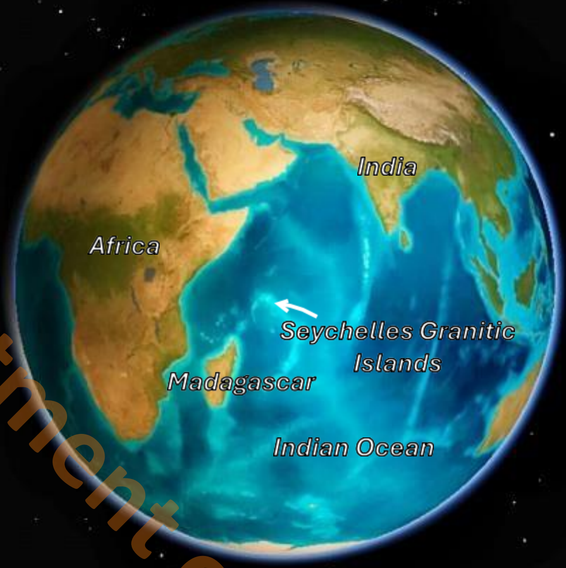
Anse Patates
La Digue

Chapter 1

The Seychelles Archipelago: A Geological Prelude

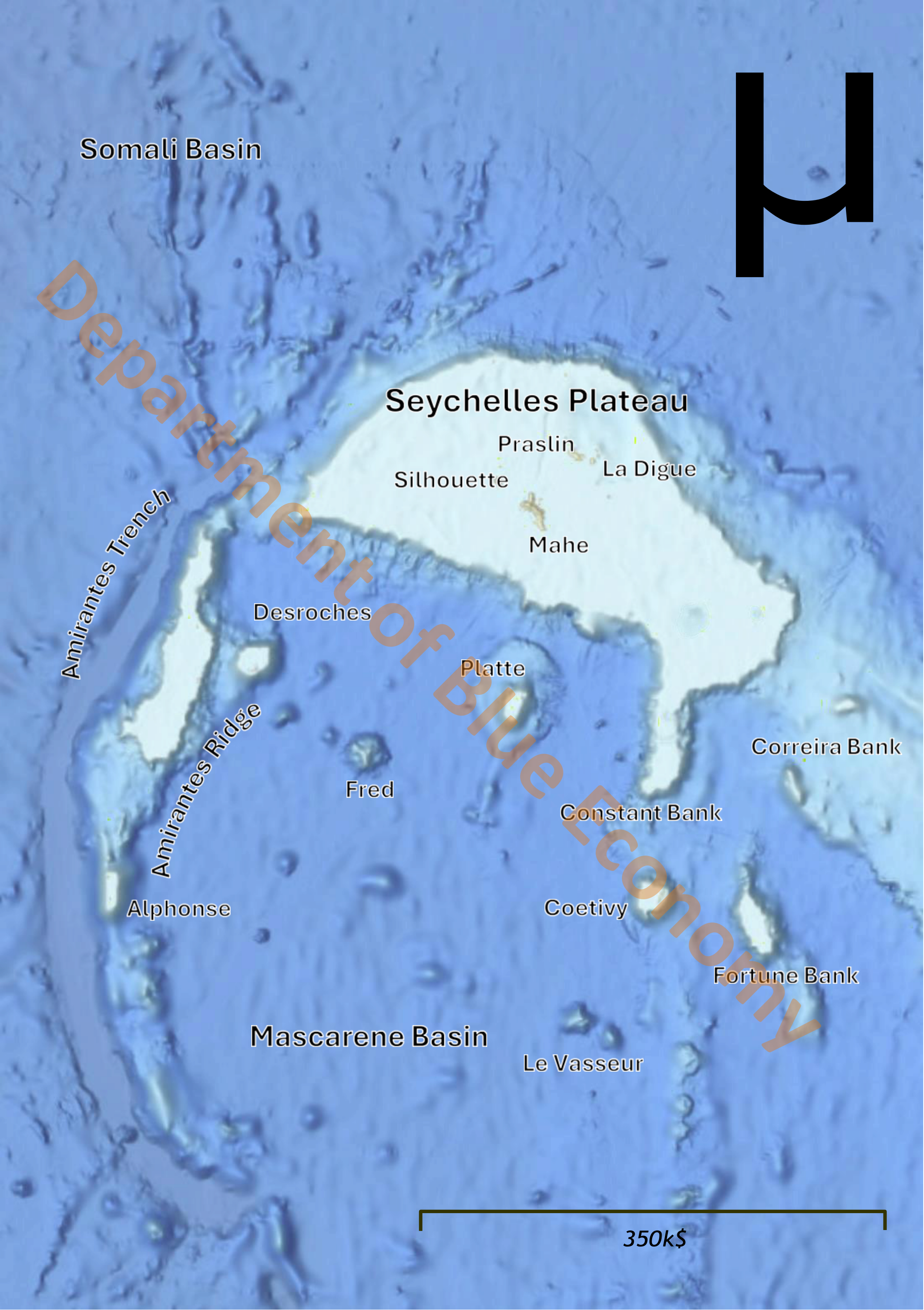
Beneath the boundless skies of the Western Indian Ocean, just south of the equator, lies a shimmering collection of islands, the verdant gems of the Seychelles Archipelago. This stunning island nation, often referred to as an earthly paradise, captivates the senses with its pristine beaches, lush tropical landscapes, and extremely vibrant marine life. Scattered across the azure equatorial waters from 1° to 12° South and 46° to 56° East, approximately 1,500km off the east coast of Africa, the Seychelles is home to around a hundred people, known as the Seychellois. These islands are more than just a tourist destination, though renowned for their unspoiled beauty and sparkling beaches they are also a living sanctuary for very rare and endemic species that have thrived through preserved ecosystems that have evolved independently in such isolation found nowhere else in the world. The famed Coco de Mer, the rare Seychelles Pitcher Plant, the elusive Black Parrot, and the iconic Seychelles Giant Tortoises are just a few examples of the extraordinary biodiversity found here.

(Present day) Plate Tectonic and Paleogeographic Maps by C. R. Scotese, ©2012, PALEOMAP Project



The geological composition of the Seychelles, however, adds a layer of intrigue to their natural beauty, especially the granitic islands, that have long been recognized for their rarity. It is unusual for granitic formations to occur in the midst of vast oceans unless they are remnants of ancient continental crust. In fact, scientific evidence has eventually revealed that the Seychelles microcontinent was once part of the supercontinent Gondwana, a primordial landmass that was part of a bigger supercontinent Pangea, began to fracture and rift over 300million years ago during the Triassic period.

The Seychelles micro-continent, though small in size compared to the larger continents, holds clues to some of the Earth's most significant geological processes and climate change events including sea level fluctuations. Beneath the lush forests and turquoise waters lies a complex geological structure that tells the story of its ancient origins. As Gondwana slowly disintegrated, the Seychelles micro-continent was left adrift, isolated, and submerged beneath the waters of the western Indian Ocean. The archipelago's geological history, therefore, is one of both creation and transformation, shaped by tectonic forces, volcanic activity, and the ebb and flow of ancient seas. A flat surface blankets the Seychelles Micro-continent, known as the Seychelles Plateau. It is relatively flat and shallow due to millions of years of carbonate deposition. This submarine plateau is a significant bathymetric feature in the western Indian Ocean region continuously encouraging high marine biodiversity. The Amirantes Ridge, a submarine volcanic arc and other bathymetric features also exist outside the boundaries of the Seychelles plateau further enhancing biodiversity. The tropical climate, marked by an annual rainfall of about 2,500mm, nourishes the islands' lush landscapes, while the archipelago's fortunate location, just outside the cyclone belt, protects it from the devastating storms that regularly sweep across the Indian Ocean.



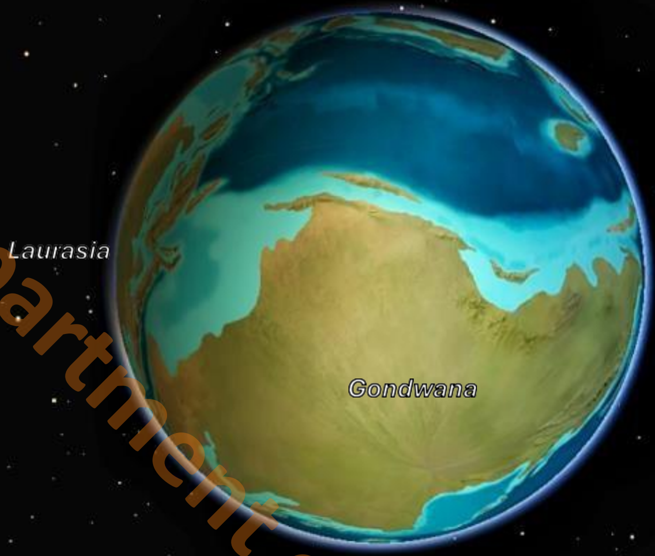
μ
Somali Basin
Seychelles Plateau
Praslin
La Digue
Silhouette
Mahe
Amirantes Trench
Desroches
Platte
Amirantes Ridge
Correira Bank
Fred
Constant Bank
Alphonse
Coetivy
Fortune Bank
Mascarene Basin
Le Vasseur
350k$

Chapter 2

The Ancient Foundations and a Fragmented Journey

Beneath the granitic islands lies a deeper story, one that reaches very far back in time. The Seychelles granite, unlike other formations found in oceanic settings, was once part of a continental mountain belt, potentially over 30km beneath the ground. This belt, formed during the amalgamation of Gondwana, has its origins in the East African Orogeny, a period of intense tectonic activity that occurred between 750 and 530 million years ago. The orogeny created large-scale shear zones, which can still be seen today in the northwest-southeast jointing patterns in the granite outcrops of Mahé, Praslin, La Digue and the rest of the granitic islands. These fault zones, weakened by ancient tectonic events, later became reactivated during the breakup of Gondwana, ultimately shaping the landscape of the islands we see today, as the erosive force of nature accelerates in these jointed zones.

(350Mya) Plate Tectonic and Paleogeographic Maps by C. R. Scotese, ©2012, PALEOMAP Project



The story of the Seychelles began millions of years ago when the supercontinent of Pangea occupied most of the land surface of the Earth at the time. Gondwana, the southern part of Pangea, which included what is now Africa, South America, Antarctica, India, and Australia, was a sprawling landmass, home to a diversity of ecosystems and a rich tapestry of life. However, tectonic forces related to mantle plume activities beneath the Earth's surface were stirring, slowly rupturing apart this immense landmass. The breakup of Gondwana is a saga of immense geological forces at play that involved a cascade of major rifting events that shaped the continents, carved new ocean basins and ultimately isolated the fragment that became part of the Seychelles.

(300Mya) Plate Tectonic and Paleogeographic Maps by C. R. Scotese, ©2012, PALEOMAP Project

It was during the Triassic period, around 300million years ago, that the slow disintegration of Gondwana began. The tectonic plates, shifting ever so slowly, started to fracture the supercontinent, initiating the separation of eastern Gondwana (comprising Madagascar, Mascarene, India, Antarctica, and Australia) from western Gondwana (which included Africa and South America). This was no sudden event, but rather over millions of years, the process of rifting would stretch, pull, and fracture the Earth's crust, leaving behind remnants of the once-united landmass scattered across the planet.

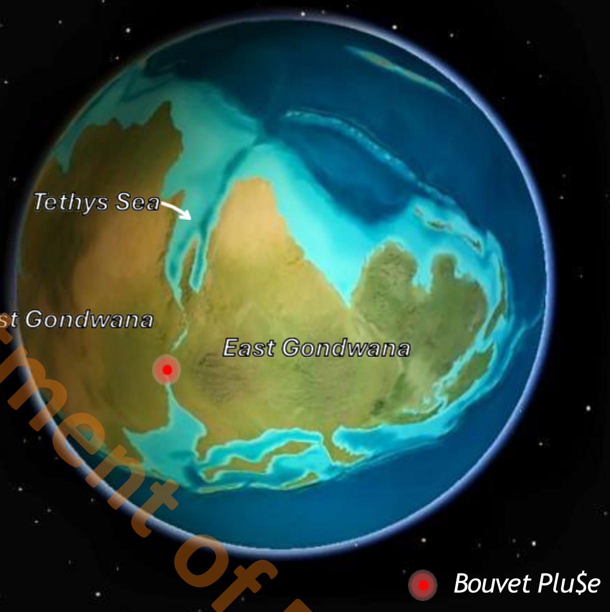
(250Mya) Plate Tectonic and Paleogeographic Maps by C. R. Scotese, ©2012, PALEOMAP Project

As rifting progressed, it created a series of elongated grabens and failed rift basins which eventually provided ample space for the deposition of thick alluvial and lacustrine deposits known as "*Karoo*" sediments across south-central Gondwana. The Karoo sedimentary sequence mainly originated from the melting of the ice caps during the deglaciation period of the ice age at the time. This permitted the formation of major rivers and lakes across the supercontinent which allowed the deposition of alternating sands and fine clay material. Over millions of years, these sediments were preserved to become sedimentary rocks in the form of sandstones and claystones. This major rifting event also permitted the formation of the Tethys Sea that protruded into Gondwana along the major rift basins.

Another phase of rifting followed between the late Triassic and middle Jurassic, around 200 to 180million years ago, likely associated with mantle processes from the Central Atlantic Magmatic Province to the north, which triggered the initial breakup of Pangea. This force was translated to the lower central part of Gondwana where it initiated rifting. This rift system led to the formation of a significant passive margin along the present-day East African coast.

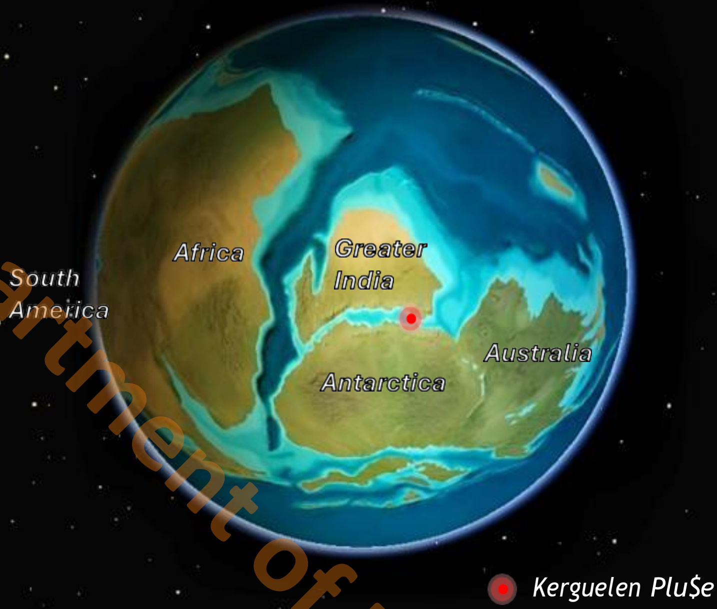
The Bouvet volcanics eventually erupted as a result of the extensional tectonics as rifting persisted and eventually resulted in the complete separation of eastern and western Gondwana and the early opening of the Indian Ocean. This extensional regime between the East and West Gondwana was facilitated by transcurrent faulting systems, including the Davie Fracture Zone between Mozambique and Madagascar, and the Owen Fracture Zone between Somalia and southwest India. Marking the Middle Jurassic is the complete breakup event of Gondwana that happened around 180 million years ago. The latter event is thus far recognized by one of the oldest recognized **seafloor anomaly** (M56) in the Somali Basin, dating back to around 156 million years ago.

(180Mya) Plate Tectonic and Paleogeographic Maps by C. R. Scotese, ©2012, PALEOMAP Project



The complete separation event between East and West Gondwana is characterized by a major marine transgression, as a result of the complete protrusion of the Tethys Sea across Gondwana that followed into the formation of the Proto-Somali Ocean basin. Following the Mid-Jurassic, rifting continued along the western edge of East Gondwana. This process introduced a shallow, confined marine environment across Central Gondwana, encompassing today's Seychelles continental fragment.

(13cMya) Plate Tectonic and Paleogeographic Maps by C. R. Scotese, ©2012, PALEOMAP Project



As East Gondwana drifted eastward, it eventually drifted over the active Kerguelen mantle plume that initiated further rifting and the eventual separation of the fragments containing Australia and Antarctica from the Greater Indian Fragment during the early Cretaceous around 136million years ago. The Greater Indian fragment included Madagascar, India, and the Mascarene Ridge along with the Seychelles fragment.

(84Mya) Plate Tectonic and Paleogeographic Maps by C. R. Scotese, ©2012, PALEOMAP Project

As drifting continued the Greater Indian fragment drifted over the Marion mantle plume which initiated further rifting and this led to the Madagascar fragment eventually separated from the rest of Greater India at around 84million years ago. A major "slide" movement between Madagascar and the Greater Indian plate, including the Seychelles fragment, facilitated this process and persisted until the early Cretaceous. As a result, the Mascarene Basin formed while the Indian Plate drifted northwards in an anticlockwise direction, away from Madagascar.

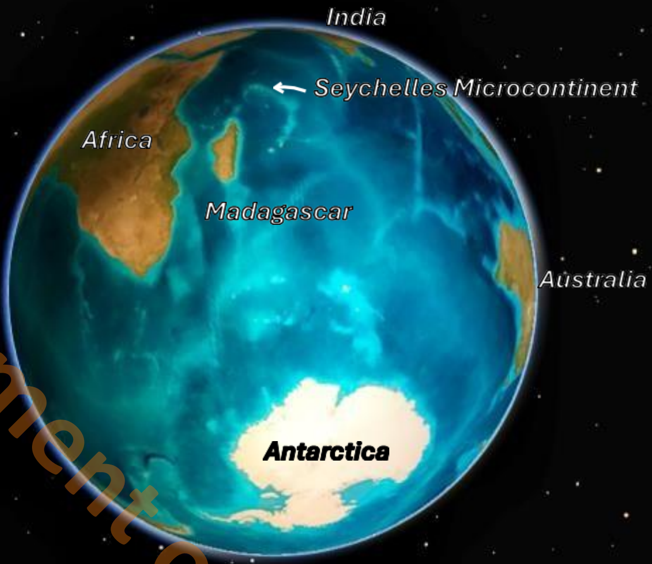
The subsequent anticlockwise motion by Greater India caused a compression zone along the western margin of the Seychelles Micro-continent which eventually led to a partial subduction between the western margin of the Seychelles fragment and the adjacent oceanic crust of the African Plate. Ultimately, this event resulted in the formation of the 550km long, curved bathymetric arc feature known as the Amirantes Ridge, which runs parallel to the Amirantes Trench that reaches depths of approximately 5200 meters below current sea level, the deepest part of the Seychelles offshore.

The Greater Indian Fragment, including the Mascarene continental fragment, continued its accelerated northward drift and eventually moved over the active Réunion mantle plume. This initiated further rifting and led to the breakup of the Mascarene fragment, including the Seychelles fragment, from the Indian fragment. This event manifested as the Deccan Volcanic eruption around 65million years ago, also known as the KT Boundary. This major volcanic event was one of the world's most violent mass extinction events, ultimately leading to the formation of the Carlsberg Ridge and the final opening of the Indian Ocean.

(c5Mya) Plate Tectonic and Paleogeographic Maps by C. R. Scotese, ©2012, PALEOMAP Project

The Deccan Volcanic event also resulted in the creation of Silhouette and North Island, the youngest igneous islands in the Seychelles compared to the much older granitic islands. These two islands, located northwest of the main island Mahé, consist of syenites, alkaline microgranites, and trachytic tuffs. These volcanic rocks from Silhouette have been dated to around 65million years, suggesting it was likely an extinct volcano formed during the Deccan Volcanic event.

(Present day) Plate Tectonic and Paleogeographic Maps by C. R. Scotese, ©2012, PALEOMAP Project



- During this new drift phase, sedimentation was dominated by open marine reefs and shelf carbonates with thicknesses over 500m that blanketed the Seychelles Micro-continent, eventually forming the Seychelles Plateau. Clastic sediments therefore became scarce due to the lack of substantial eroding sources from nearby land masses, as the Seychelles continental fragment had become too isolated to provide significant clastic input as it drifted southeast into further isolation. Simultaneously the Indian fragment drifted north where it eventually collided into the Eurasian plate leading to the formation of the Himalayan Mountain belt.

Anse Boileau
West coast Mahe

Chapter 3

The Mysterious Islands: A Geological Enigma

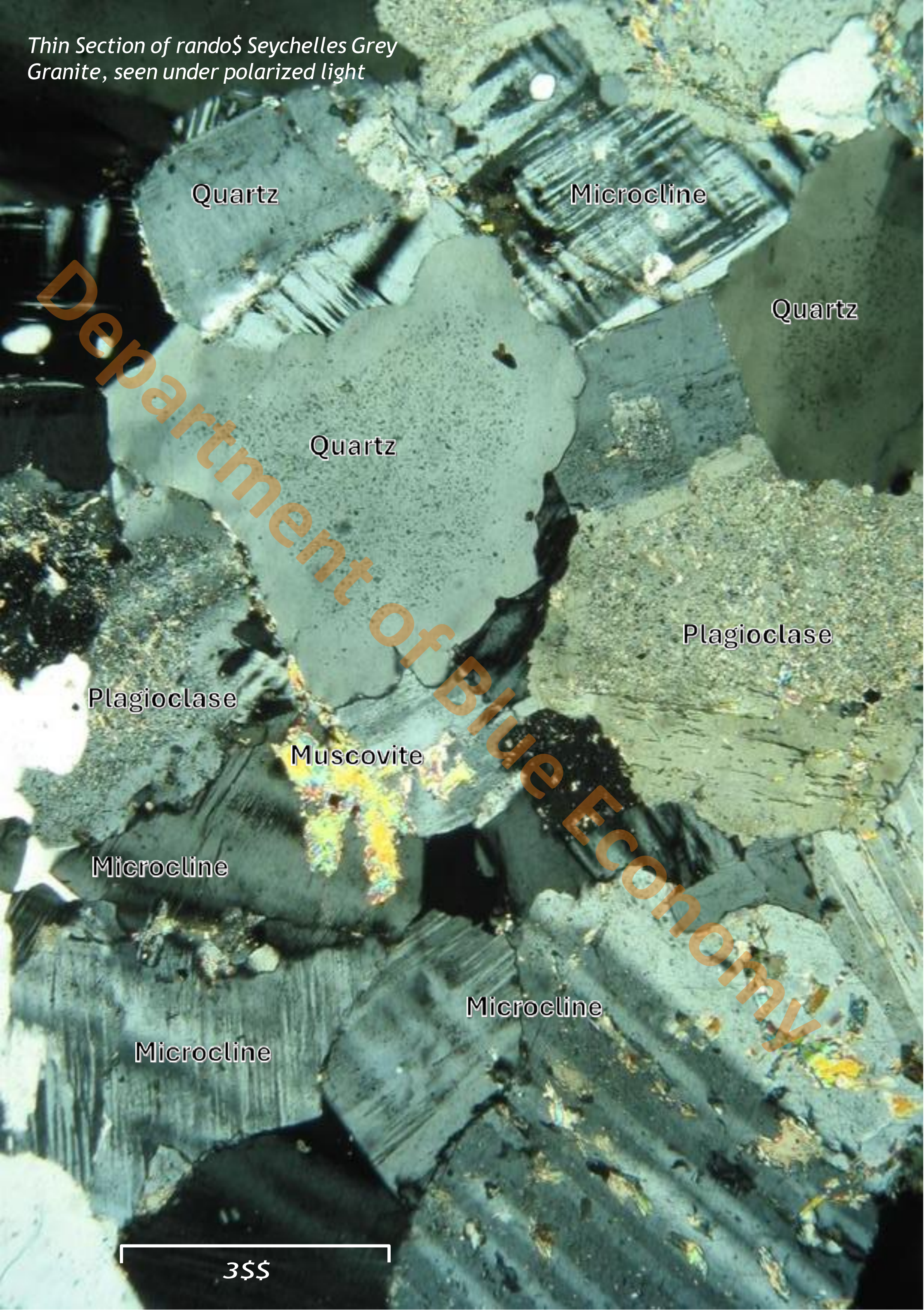
The Seychelles today is not a singular landmass but a diverse collection of islands, it is an archipelago which is geologically divided into two main groups: the Granitic and Coralline islands. Of the 115 islands, 41 are granitic, located within the boundaries of the Seychelles Plateau and are classified as the *"Inner Islands"*. These islands, steep, jointed and rugged, are characterized by mountainous topography with narrow, flat coastlines blanketed in calcareous and siliceous sands. The island of Mahé, the largest of the group, rises dramatically to its highest point at 905 meters above sea level, while measuring 27km long and 7km wide at its broadest point only. As the largest, most developed and most accessible of the Seychelles archipelago, Mahe's landscape serves as a primary focus to this book. The mapped joint sets of Mahe is presented at the end of this book, illustrating the scars within the geology in the form of joints left behind by the past tectonic events. These joints usually channel water during rainy periods, it is therefore a critical factor to pay close attention to.

Taka$aka
Southwest Mahe

The granitic islands of the Seychelles are unlike most other islands in the world. While the majority of the world's islands are volcanic in origin, formed by old eruptions of underwater volcanoes that erupted and pushed lava above the ocean's surface, the Seychelles' granitic islands are remnants of continental crust, a rare geological feature in the midst of the Indian Ocean. This uniqueness has fascinated geologists for decades, as the Seychelles stands as one of the only places where granitic islands exist in isolation, far and completely disconnected from any major continental landmass. These granites show a strong chemical similarity to the plutonic rocks of Madagascar and western India. This correlation supports the idea that the Seychelles granites originated from the same province during the amalgamation of the Pangean sub-continent, Gondwana.

Ile Cocos
La Digue

The granite that forms the bedrock of the Seychelles is ancient, dating back some 750million years, during the period of Gondwana's formation. This crystalline rock that makes up the granitic islands is part of a larger and extremely stable mass referred to as a pluton, the Seychelles Micro-continent. The granitic islands, with their rugged cliffs, steep hills, and massive boulders, are a testament to the endurance of this ancient rock. How have such granitic rocks that usually forms at great depth beneath the surface are now outcropping in the Seychelles? Since the Seychelles is relatively small, during its last break-up event from the Great Indian continental fragment, the Seychelles micro-continent uplifted and eventually unveiled deeper rocks to the atmosphere. The topmost sedimentary layers along with a huge chunk of crystalline granite basement was therefore removed by the forces of weathering and erosion ultimately allowing the basement to be expose as outcropping peaks above the sea level, seen as our granitic islands today.


Thin Section of rando$ Seychelles Grey
Granite, seen under polarized light
Quartz
Microcline
Quartz
Quartz
Plagioclase
Plagioclase
Muscovite
Microcline
Microcline
Microcline
3$$

These islands are known to be the oldest and the only granitic islands in the world. The primary granites in the Seychelles are un-metamorphosed alkali granites, characterized by an abundance of phenocrysts of microcline with microperthites, irregular aggregates of clear and smoky quartz, sparse aggregates of fibrous amphiboles, and common accessory minerals such as barite, sphene, apatite and muscovite.

Basaltic and dolerite dykes are also present within the granitic islands of the Seychelles, often seen cutting across the main outcrops of the Granitic Islands of Mahe. Zircon dating of the primary basaltic dykes on Mahé indicates they formed approximately 65 million years ago. This intrusion date aligns with the Deccan volcanic eruption event, associated with the separation of the Seychelles continental fragment from Greater India. Basically, the jointed continental fragment got exposed to the Deccan plume from beneath which was the initial cause of separation but this event also allowed lava to rise and solidify in between the expanded joints sets, ultimately forming the spectacular dykes and sills. Paleomagnetic analysis of older dykes places the granites of the Seychelles on the north-western side of India and north-east of Madagascar before the fragmentation of Gondwana, further attesting to the continental origins of the Seychelles.

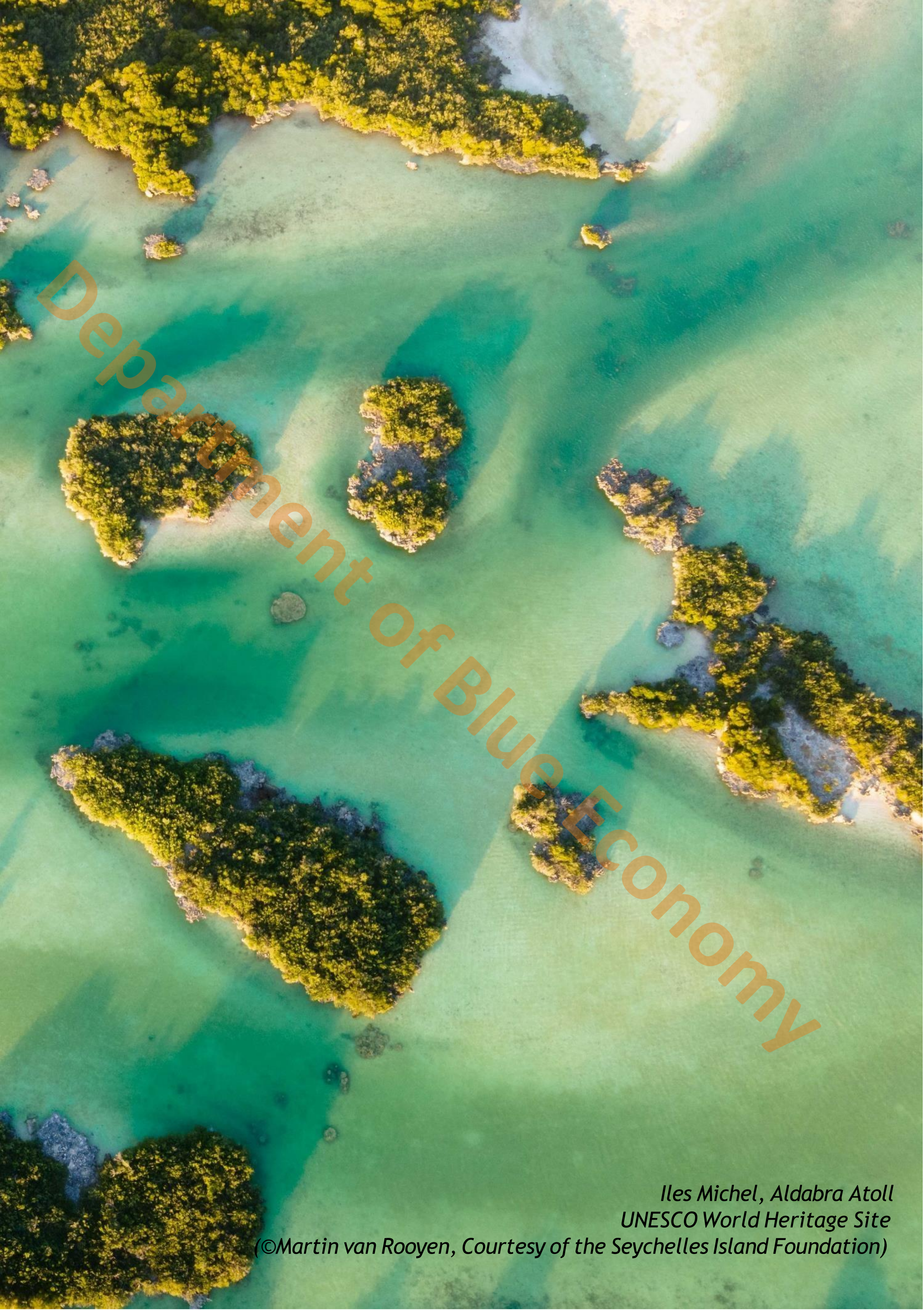
Passe Fe$$e, Aldabra Atoll
UNESCO World Heritage Site
(©Martin van Rooyen, Courtesy of the Seychelles Island Foundation)

The granitic islands are not the only geological marvels of the Seychelles. The 74 Coralline islands, are biochemical sedimentary rocks formed by the accumulation of coral reef-building organisms over millions of years as a consequence of varying sea levels and the gradual subsidence of the ocean floor. They are low-lying, flat atolls covered by calcareous sands with elevations rarely exceeding **6m** above sea level. These islands reside far from the granite heart of the Seychelles, outside the boundaries of the Seychelles plateau, and are classified as the Outer islands. These coralline islands are mainly originating from isolated seamounts, remnants of ancient submarine volcanoes and seafloor spreading activities. Initially these coral reefs chose to grow over these bathymetric features where it was within or closer to the photic zone for sunlight. They therefore provide a stark contrast to their rugged granitic neighbours, both in morphology and formation origins. Only two of the coralline islands reside on the northern edge of the Seychelles Plateau, namely Bird island and Denis Island.

Passe Fe$$e, Aldabra Atoll
UNESCO World Heritage Site
(©Martin van Rooyen, Courtesy of the Seychelles Island Foundation)

The formation of the Seychelles islands is intricately tied to the rifting events that occurred during the breakup of Gondwana. As the ancient landmass fractured, the Seychelles were subjected to complex tectonic forces that shaped not only the seafloor but also the very structure of the granitic islands themselves. For millions of years, the microcontinent drifted and subsided, while volcanic activity, sedimentation, and coral growth continued to transform the landscape. Despite their differences, the granitic and coralline islands are part of the same geological story, one that began with the breakup of Gondwana and continues to this day. The tectonic forces that shaped the Seychelles are still at work, as the islands slowly drift across the Indian Ocean. This slow movement, coupled with the ever-present forces of erosion, ensures that the landscape of the Seychelles is constantly evolving, even if the changes are imperceptible to the human eye.

The islands of the Seychelles are more than just a product of geological time, they are truly a manifestation of the Earth's dynamic processes. Over time, as the Indian Ocean basin grew larger with the separation of Gondwana, the Seychelles micro-continent found itself caught between tectonic events. These movements, particularly the separation of East and West Gondwana, Madagascar from Greater India, further isolated the Seychelles Micro-continent, leaving it adrift in the vast ocean. Each of those rifting events have left their signatures hidden within the Seychelles Plateau.



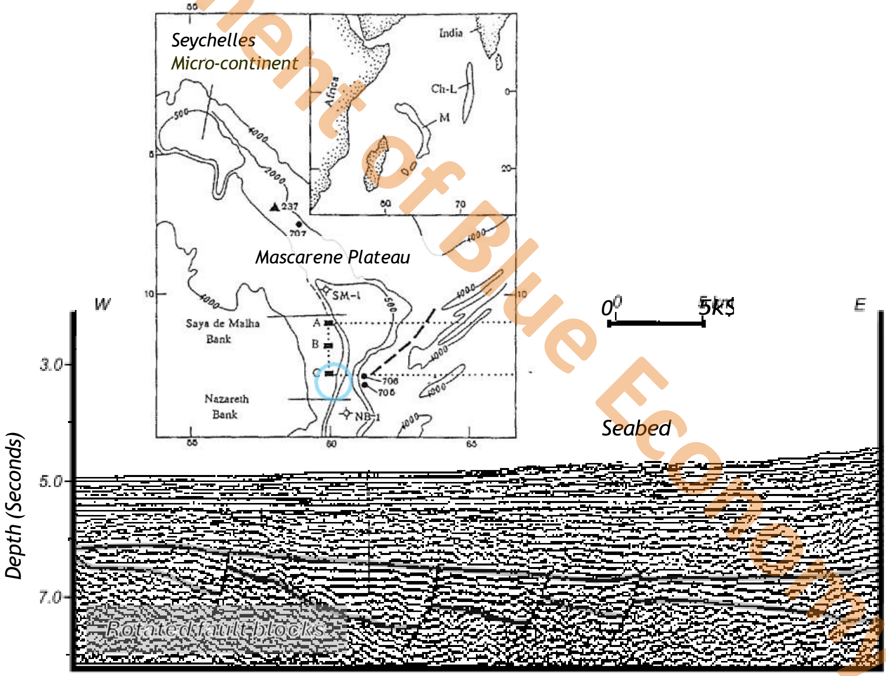
Iles Michel, Aldabra Atoll
UNESCO World Heritage Site
(©Martin van Rooyen, Courtesy of the Seychelles Island Foundation)

Chapter 4:

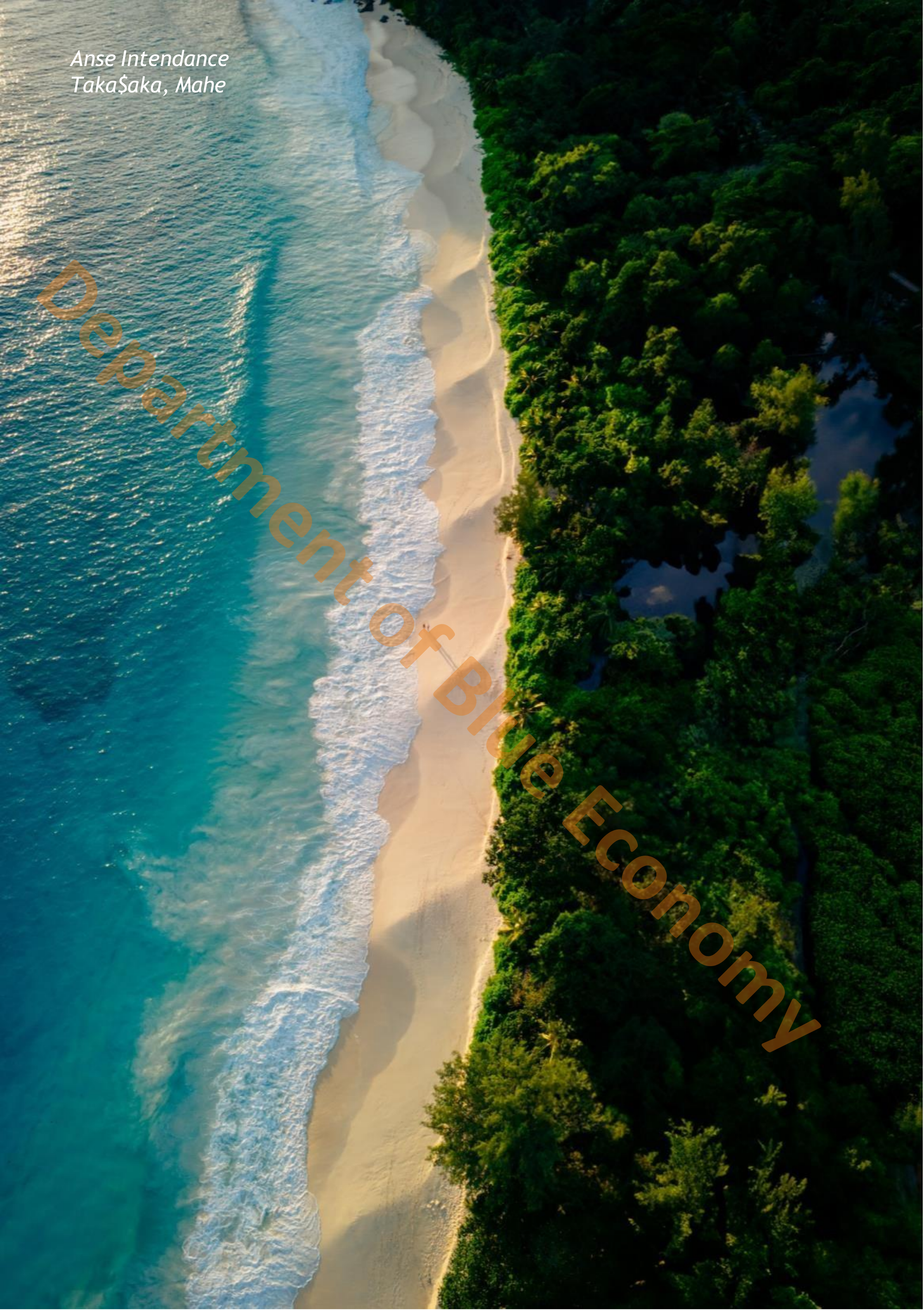
Exploring the Depths: Offshore Geological Discoveries

In the early 1980s, a new chapter in the geological exploration of the Seychelles began when the Amoco Seychelles Petroleum Company undertook drilling operations on the southwestern shelf of the Seychelles Plateau. Their goal was to explore the possibility of oil deposits within the Seychelles Plateau, but what they discovered was far more significant. Three exploration wells were drilled on the western Seychelles Plateau, namely Owen Bank - A1, Reef Bank - 1, and Seagull Shoal - 1. These wells revealed thick layers of sedimentary rock, dating back to the Mesozoic and Cenozoic eras, providing further evidence of the continental origin of Seychelles, except for a fourth well, Constant Bank - 1, that was drilled in 1995 by Enterprise Oil in 1995. This fourth well encountered thick carbonate and volcanic layers, so they decided to abandon the project.

The discovery of these sedimentary layers confirmed what geologists had long suspected, that the Seychelles micro-continent had once been part of a larger landmass. Early regional seismic surveys also depicted the presence of rotated fault blocks and thick sedimentary successions that pointed to the tectonic forces that had shaped the region during the breakup of Gondwana. These findings deepened the understanding of the Seychelles' geological history but also opened the door to further exploration of the region's potential as a source of petroleum.



Part of a reflection seis$ic profile west of Sal De Malha Bank in the early 1S80s (Yuz$orgeologiya Survey), illustrating rotating fault block features deep beneath the seabed; After such results fro$ the refractive studies, continental crust origins of the Mascarene ridge was i$$ediately assu$ed, and the Seychelles plateau is part of the Mascarene Ridge.

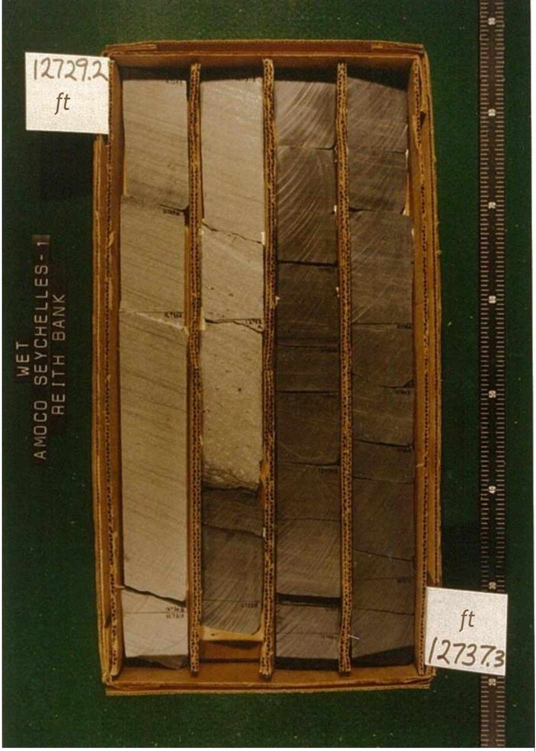

Anse Intendance
Taka$aka, Mahe

Palynomorph evidence, including dinocysts, acritarchs, spores, and pollen, was identified from the wells drilled on the western shelf of the Seychelles Plateau in the early 1980s. These palynomorphs are generally older than most of the foraminiferal species found. Most of the palynomorphs date back to the Mesozoic and early Cenozoic eras. Their presence, along with the absence of foraminifera in the Mesozoic sections, suggests primarily terrestrial depositional environments during much of the Mesozoic and early Cenozoic eras. The foraminiferal fossils found in the upper sections of the well data are mostly from the Cenozoic era, indicating predominantly marine environments. Both benthic and a few planktonic foraminifera were identified. Benthic foraminifera lives on and within the basin floor substrate, indicating shallow marine environments such as estuaries, intertidal zones, reefs, and lagoons. In contrast, planktonic foraminifera live in the upper part of the water column in open oceans, indicating deeper marine environments such as continental shelves and deep ocean basins. Most planktonic foraminifera species are found in the uppermost part of the wells, indicating increased water depth throughout most of the Paleogene period.

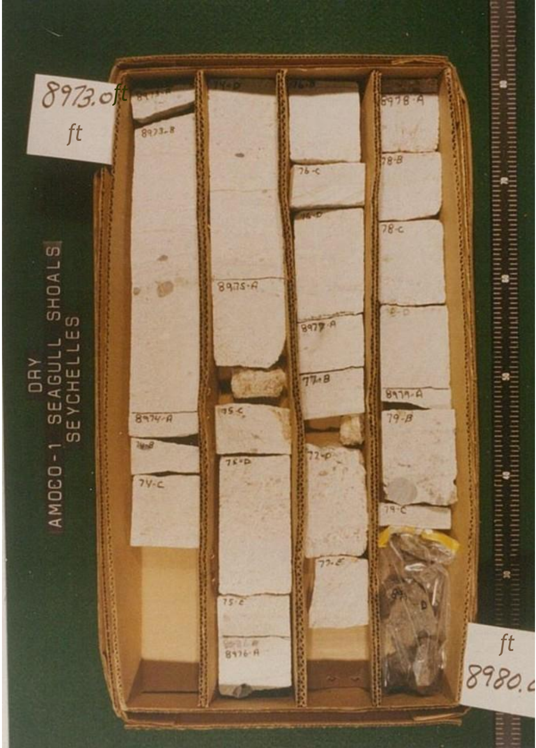
The overall stratigraphy of the Seychelles continental fragment mirrors that of a typical passive margin. The paleo depositional environment and rock types of the sedimentary basin that the Seychelles continental fragment was once a part of include Mesozoic and Cenozoic sediments. The base of these sediment layers is primarily characterized by extensional fault structures. Above these layers lie sequences formed by thermal subsidence deposited during the break-up regime, which generally show a progression from terrestrial to marine sediments within the syn-rift, and post-rift phases.

The oldest and deepest rocks encountered by the wells drilled on the western shelf of the Seychelles plateau are equivalent to the "*Karoo Supergroup*". As previously mentioned, these rocks are believed to have formed as a result of a significant deglaciation event in the Mid Permian period, which led to continental fluvial processes like rivers and lakes from the Mid Triassic to Early Jurassic as Gondwana drifted away from the polar region. The Karoo Supergroup sediments consist mainly of fluvial sandstones with planar cross-bedding, fining upward trends, and conglomeratic bases, as well as lacustrine sediments like claystones and siltstones. The wells on the western Seychelles plateau did not penetrate to the base of this sequence, which is why no glacial sediments were recorded.

Core Photographs fro$ Owen Bank – A1:
So$e of the deepest sedi$entary rocks, na$ely claystones of lacustrine origins



Core Photographs fro$ Reith Bank - 1:
So$e of the deepest sedi$entary rocks, na$ely claystones of lacustrine origins



Core Photographs fro$ Seagull shoals – 1:
So$e of the deepest sedi$entary rocks, na$ely claystones and siltstones of lacustrine origins

A distinct oolitic limestone horizon signifies the beginning of the Mid-Jurassic period which marks the onset of a marine incursion event associated with the progression of the Tethys Sea, which advanced southward along major rift basins. This oolitic limestone marker is visible in all three wells of the Western Seychelles Plateau. It can be correlated regionally, being observed as far south as South Africa and as far north as the Horn of Africa, Somalia. This indicates the extent of the marine incursion from the Mid-Jurassic onwards. This marine incursion followed the extensional rift systems linked to the separation of East and West Gondwana.

The period from the Middle Jurassic to the Cretaceous saw an abundance of calcareous clastics, such as marine siltstones, claystones, and sandstones, as well as carbonates, in central Gondwana around 240 – 200 million years ago. These areas were characterized by low energy, providing a suitable sheltered environment for benthic and neritic organisms, and ample accommodation space for the deposition of fine-grained, organic-rich sediments, such as the dark organic-rich claystones. These organic-rich rocks were deposited in deltaic coastal plain environments during the later stages of rifting that eventually led to the split between East and West Gondwana.

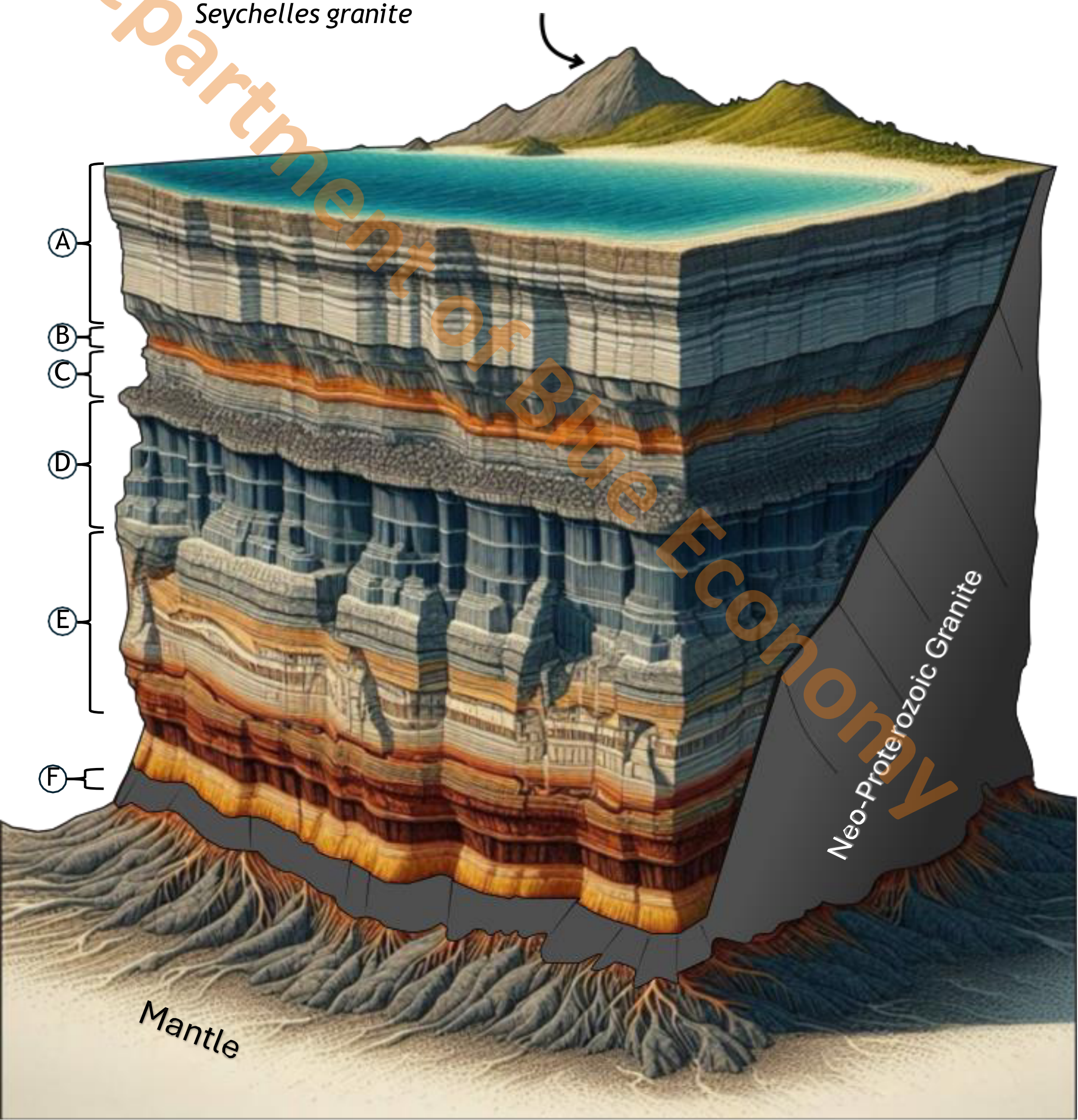
The late Mesozoic sedimentary successions preserved in the Seychelles continental fragment consist of limestone, calcareous claystones, and thin bands of volcanic ash, interspersed with thick volcanic strata. These volcanic layers include welded tuffs and ash, basaltic lava, dacite, and andesite from the late Cretaceous period. The initial calcareous deposits in this sequence formed as part of marine shelf carbonates, comprising limestone, calcareous claystones, and sandstone. The dacite and andesite layers likely originated from partial subductions during the breakup of Madagascar from Greater India around 84 million years ago, leading to the formation of the Amirantes Ridge and Trench complex. The basaltic lava in this sequence is most linked to the Deccan volcanic eruptions when the Seychelles separated from India, about 65 million years ago.

The remaining stratigraphy of the Seychelles plateau consists of post-rift Paleogene marine clastics, including calcareous claystones interbedded with calcareous sandstones and dolomitic limestones. These limestones generally represent carbonate platform deposits that accumulated as the Seychelles moved to their current location.

Stratigraphy of the Seychelles Plateau

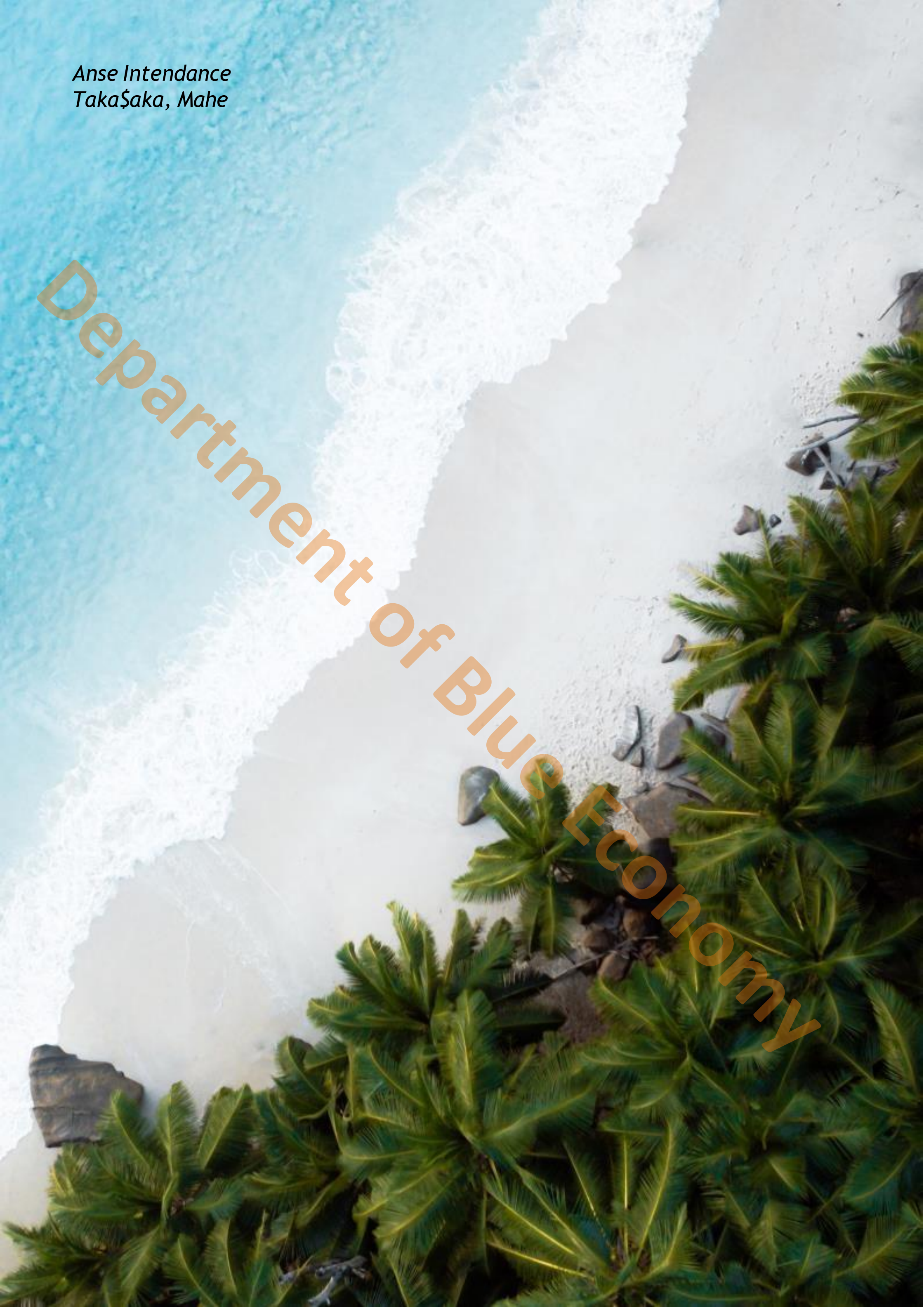
- Ⓐ *Cenozoic Li$estone*
- Ⓑ *Late Cretaceous Volcanics*
- Ⓒ *Mid Cretaceous Li$estone*
- Ⓓ *Mid to Late Jurassic Marine Sandstone and Claystone*
- Ⓔ *Mid Triassic to Early Jurassic Sandstone and Claystone*
- Ⓕ *Neo-Proterozoic Granite (~750 Mya)*

Seychelles granite



The confirmation of a submerged continental crust beneath the Seychelles was a landmark discovery. It reinforced the idea that the Seychelles was not just a collection of tropical islands but a fragment of a much larger geological puzzle, a piece of the ancient world, preserved beneath the waters of the Indian Ocean. While this discovery unveiled the possibility of exploiting the Seychelles' geological resources, it also led to a broader understanding of the complex tectonic history that shaped the region. The drilling operations not only confirmed the existence of a submerged continental crust but also highlighted the intricate geological layering and joint systems that make the Seychelles such a unique geological phenomenon.

The story of the Seychelles is not only one of ancient origins but also of modern potential. The discovery of thick sedimentary successions and rotated fault blocks beneath the Seychelles micro-continent has sparked interest in the potential for oil and gas exploration. While the primary focus of these explorations has been on the extraction of fossil fuels, the very act of drilling into the Earth has provided a wealth of data that has helped geologists understand the deeper layers of the Seychelles' geology.


Anse Intendance
Taka$aka, Mahe

Chapter 5

A Geological Heritage

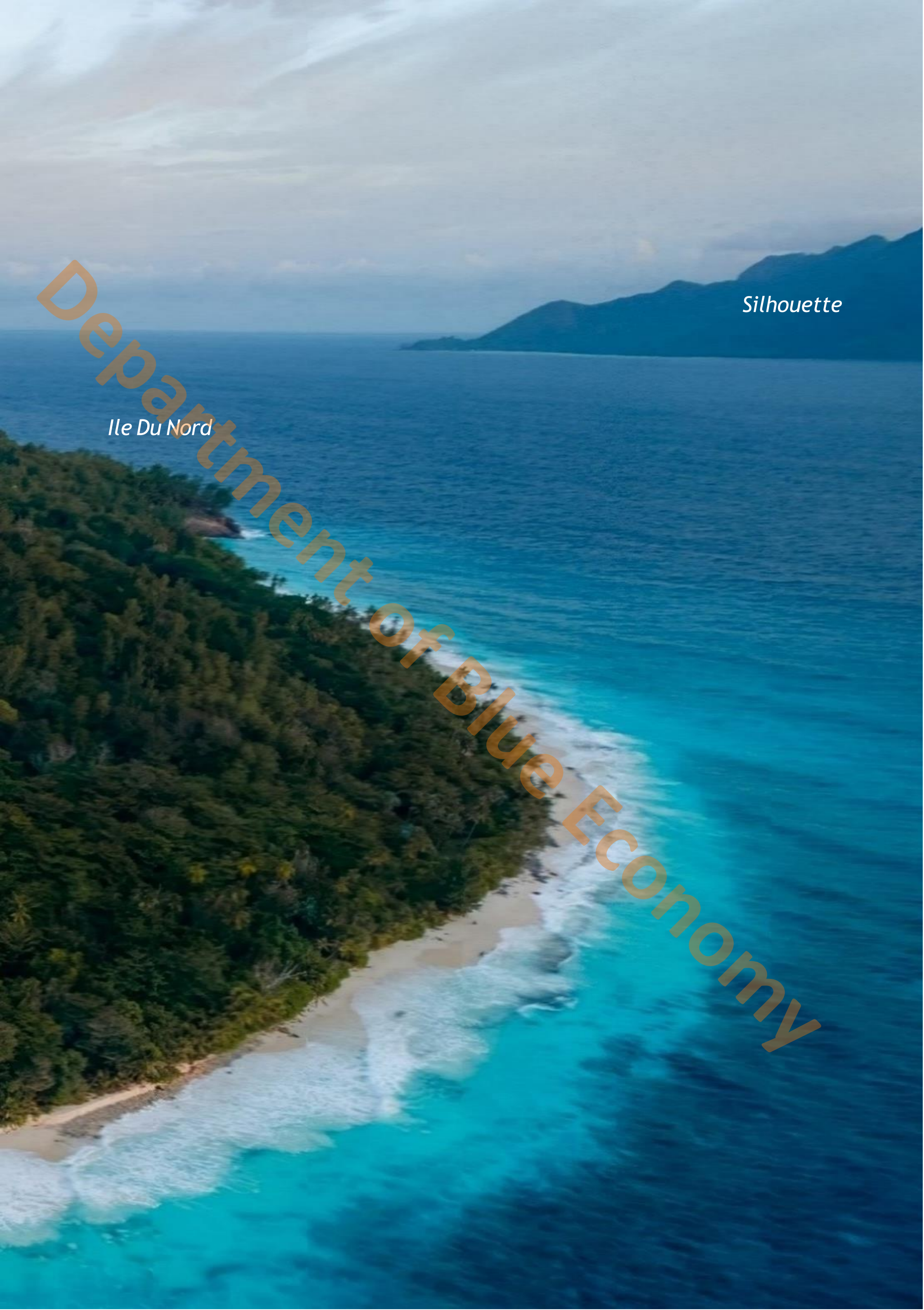
The unique geological history of the Seychelles has given rise to some of the most stunning natural landscapes on the planet. The towering granite ridges and massive granitic boulders that line the beaches of Mahé, Praslin, and La Digue are among the most iconic features of the islands. These massive rock formations, weathered by time and the elements, stand as silent sentinels of the islands' ancient past. The beaches themselves are composed of fine, white sand, sand that has been shaped by the weathering of granitic rocks and coral over millions of years. The remote location and unique geological past of the Seychelles have fostered the creation of vibrant marine ecosystems, shaped by a complex and extremely distinctive bathymetry.

The unique geology coupled with the climatic conditions of the Seychelles have played a crucial role in shaping the islands' ecosystems. The steep mountains, flat atolls, and coral reefs provide a wide range of habitats, each supporting its unique flora and fauna. From the mist-covered forests of Mahe's highest peaks to the shallow lagoons of the outer islands, the Seychelles is indeed a living laboratory for scientists studying the interaction between components of earth sciences.

Anse Boileau Estuary

The coral reefs that surround the Seychelles islands are another geological marvel. These reefs, are amongst the healthiest and most diverse in the world, teeming with diverse marine life, including over a hundred species of fish and a variety of invertebrates. The warm, nutrient-rich waters surrounding the islands promote coral growth and support marine biodiversity. These coral ecosystems are crucial, not only for their ecological roles but also for protecting the islands from erosion and providing habitats for numerous marine species, thus maintaining the overall health of the coastal environment, a sought-after destination for travellers and scientists alike.

The Seychelles such isolation had become home to a rich and various forms of flora, with over a hundred species of plants that are found nowhere else on Earth. The islands' vegetation ranges from coastal mangroves to thick tropical rainforests. Among the most famous of these endemic plants is the Coco de Mer, which produces the largest seed in the world and is found only on the islands of Praslin and Curieuse. This iconic palm has become a symbol of the Seychelles. Another notable endemic species is the Seychelles Pitcher Plant, thriving in the moist, shaded forests of Mahé and Silhouette. These and many other unique plants have flourished in the tropical climate of the islands.


Silhouette
Ile Du Nord

The fauna of the Seychelles islands is equally impressive. The islands host a variety of unique species, such as the Seychelles Black Parrot, the national bird. The Aldabra Giant Tortoise, found on the Aldabra Atoll, is one of the largest tortoises globally and serves as an iconic symbol of the Seychelles. The archipelago also supports numerous species of reptiles, amphibians, and insects that exist nowhere else. Conservation efforts in the Seychelles have been crucial in protecting these species and their habitats, establishing the islands as global leaders in biodiversity preservation.

Like any other nation, the Seychelles face ongoing challenges in preserving their environmental integrity, including changing weather patterns that affect both terrestrial and marine ecosystems. The reliance on tourism also necessitates a balance between economic growth and environmental sustainability.

While the geological story of the Seychelles is one of ancient forces and slow-moving processes, the human story is far more recent but no less fascinating. The arrival of humans on the islands, in the 18th century, brought a new chapter to the Seychelles' history, one in which people would come to live in harmony with the unique geological and natural landscape.

AI Generated

Human history in the Seychelles is relatively recent, with no known indigenous populations before European explorers arrived. Portuguese explorers first charted the islands in the early 16th century, but it wasn't until the 18th century that the French established a settlement within the inner islands (1770). The French brought African slaves to work on plantations, creating a cultural mix that laid the foundations for the Seychellois Creole culture seen today. The British took control of the islands in the early 19th century, 1810, abolished slavery, and the Seychelles remained a British colony until achieving independence in 1976.

Since gaining independence, the Seychelles has evolved into a stable and prosperous nation. The economy, initially based on plantations and fishing, has diversified into tourism and offshore finance. The country's stunning natural beauty attracts visitors worldwide, significantly boosting national income. Despite modernization, the Seychellois have maintained their rich cultural heritage, with Creole traditions, music, and cuisine central to daily life. However, the Seychelles' commitment to conservation offers a hopeful outlook, as they continue to adapt and innovate in their efforts to protect their unique environment.

The Seychellois people have long recognized the importance of their islands' geology. The granite boulders and coral reefs have not only shaped the physical landscape but also the culture and economy of the islands. The granitic mountains provide fertile soil for agriculture, while the coral reefs offer protection from the sea and a bountiful source of fish. The natural beauty of the islands, born of their geological heritage, has also made the Seychelles a world-renowned tourist destination, drawing visitors from all corners of the globe to experience the pristine beaches and vibrant marine life.

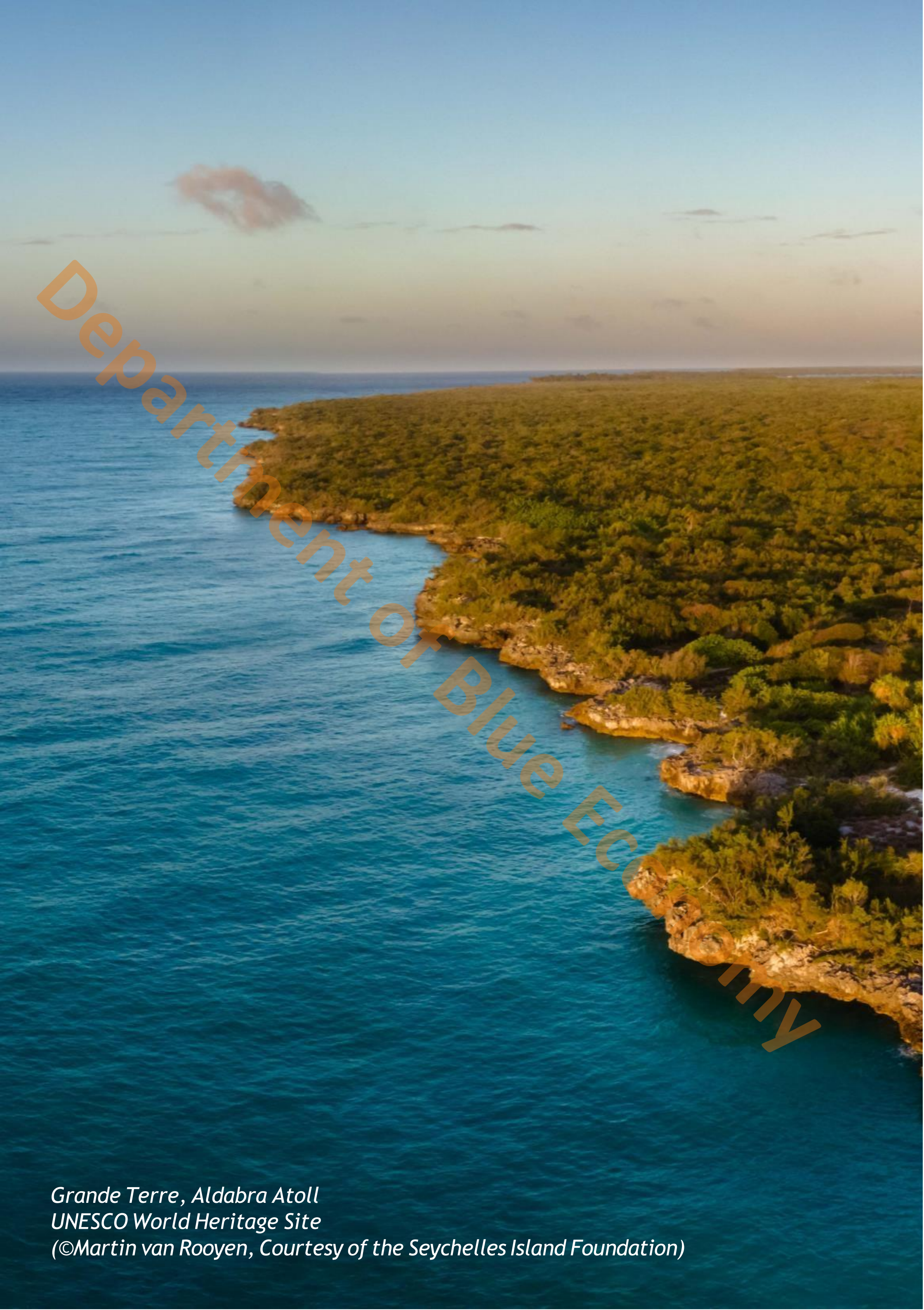
Being so distinct from the rest of the islands of the world today, the Seychelles granitic islands have been shaped by its own unique geological and ecological processes resulting in such breadth taking landscapes like no other. This extraordinary isolation has led to scientific phenomena that continue to intrigue our understanding, making the Seychelles a truly exceptional environment. The Seychelles granitic islands, are indeed testaments to the intricate and dynamic processes that exist in the Earth's climate. From its origins as part of the basement of the ancient supercontinent Gondwana to a small island state originating from the pinnacles of this ancient crystalline basement, the Seychelles' story is one of remarkable natural history. Looking to the future, the Seychelles continue to inspire and remind us of the importance of preserving our planet's precious environments for generations to come.

Ile De Ro$ainville
East Coast Mahe

The Seychelles have also gained recognition for their proactive approach to conservation and sustainability. Acknowledging the importance of their unique ecosystems, the government and local organizations have implemented numerous conservation initiatives. Marine parks and nature reserves have been established to protect the islands' biodiversity. Organizations like the Seychelles Islands Foundation work to safeguard critical habitats and endangered species. Recently, a Marine Spatial Plan has been developed to better manage the Seychelles' blue economy, a new opportunity in becoming more sustainable.

In recent years, the emphasis has shifted somewhat from traditional oil exploration to more sustainable forms of energy. The Seychelles government, in partnership with international researchers, has begun exploring the possibility of harnessing renewable energy sources such as hydrogen, offshore wind and solar power. These initiatives, driven by both economic and environmental considerations, represent the next phase in the islands' long-standing relationship with their geological resources.

The beauty of the Seychelles comes with a natural fragility, an inherent vulnerability tied to its isolation and unique geological formation. While the granitic islands have stood firm for millions of years, the changing climate of the 21st century introduces new challenges that threaten to alter the landscape, the environment and ultimately the inhabitants of the islands. Rising sea levels and stronger storm surges, driven by global climate change, pose a significant risk to the coralline islands and atolls, and the coastal plains of the granitic islands. These areas, some of which are only a few meters above sea level, face the very real threat of submersion as the eustatic sea level continues to rise as a result of the polar ice caps that continue to melt. This is inevitable as the earth entered a deglaciation period about 20,000 years ago. As a result, the low-lying coastal realms end up experiencing coastal erosion, exacerbated by increasingly intense storms and coastal development, is also scouring away at the beaches and low-lying sandy coastal plains that make the Seychelles a tropical paradise.



Grande Terre, Aldabra Atoll
UNESCO World Heritage Site
(©Martin van Rooyen, Courtesy of the Seychelles Island Foundation)

The threat extends beyond the visible coastline as the health of the Seychelles' coral reefs, so critical to the islands' ecosystem and economy is compromised by increased ocean acidification, warmer climatic conditions, and rising pollution. As the corals bleach and die, the reefs that once served as natural barriers protecting the islands from storm surges weaken, leaving the shores of the islands more exposed to the erosive power of the ocean. Geological features that took millions of years to form may be forever altered within a few decades.... Or is this just part of the cycle? Nevertheless, the Seychelles granitic islands remain a thermometer in the vastness of the Western Indian Ocean as a witness to global climatic changes.

Passe Du Bois, Aldabra Atoll
UNESCO World Heritage Site
(©Martin van Rooyen, Courtesy of the Seychelles Island Foundation)

Glossary

Acritarch: Fossil of one-celled marine planktonic organisms

Alkali Granite: A type of granite rich in alkaline elements like sodium and potassium.

Amygdaloidal Basalt: A volcanic rock with small, rounded cavities filled with minerals.

Amphiboles: A group of minerals found in igneous and metamorphic rocks, often dark and fibrous.

Basement Rock: The oldest rock layer, forming the foundation below surface layers.

Bathymetry: The study and mapping of the depth of ocean floors and underwater features.

Bioturbation: Disruption of sediment layers by living organisms.

Calcareous: Composed of or containing calcium carbonate.

Carbonate Platform: A shallow marine area where carbonate sediments accumulate.

Cenozoic: The current geological era, starting about 66 million years ago.

Continental Crust: The Earth's crust that forms the continents, thicker and less dense than oceanic crust.

Devitrified: When volcanic glass changes into a crystalline form over time.

Dinocyst: Fossil of one-celled marine algae

Dolerite: A dark, igneous rock similar to basalt, often forming in dikes.

Dyke: A slab of volcanic rock that cuts through layers of surrounding rock.

Extrusive: Igneous rocks formed from magma that cools on the Earth's surface.

Facies: Distinct rock units that form under specific environmental conditions.

Foraminifera: Tiny marine organisms with shells, used to study past environments.

Glauconite: A green mineral found in marine sediments, indicating slow sedimentation.

Granitoid: A group of coarse-grained igneous rocks similar to granite.

Igneous: Rocks formed from the cooling of molten magma.

Intrusive: Igneous rocks formed from magma that cools within the Earth.

Isobath: A line on a map connecting points of equal water depth.

Karoo Supergroup: A sequence of sedimentary rocks from the Paleozoic to the Mesozoic era in southern Africa.

Lacustrine: Related to or found in lakes.

Lithostratigraphy: The study of rock layers based on their physical characteristics.

Mantle Plume: An upwelling of hot rock from deep within the Earth's mantle.

Micro-continent: A small, isolated landmass that has drifted from a larger continent.

Mya: Million years ago

Neoproterozoic: The last part of the Precambrian, around 1,000 to 541 million years ago.

Oolitic: Composed of small, round grains resembling fish eggs, often found in limestone.

Paleogeography: The study of historical geography, especially of ancient lands and seas.

Paleomagnetic: Relating to the magnetic properties of rocks to study past positions of continents.

Phenocryst: A large crystal in igneous rock, visible to the naked eye.

Rifting: The process of a landmass splitting apart, forming new geological features.

Pluton: A body of intrusive igneous rock.

Pyrite: A yellow, metallic mineral often called "fool's gold."

Seamount: A mountain rising from the ocean floor that doesn't reach the surface formed through seafloor spreading processes.

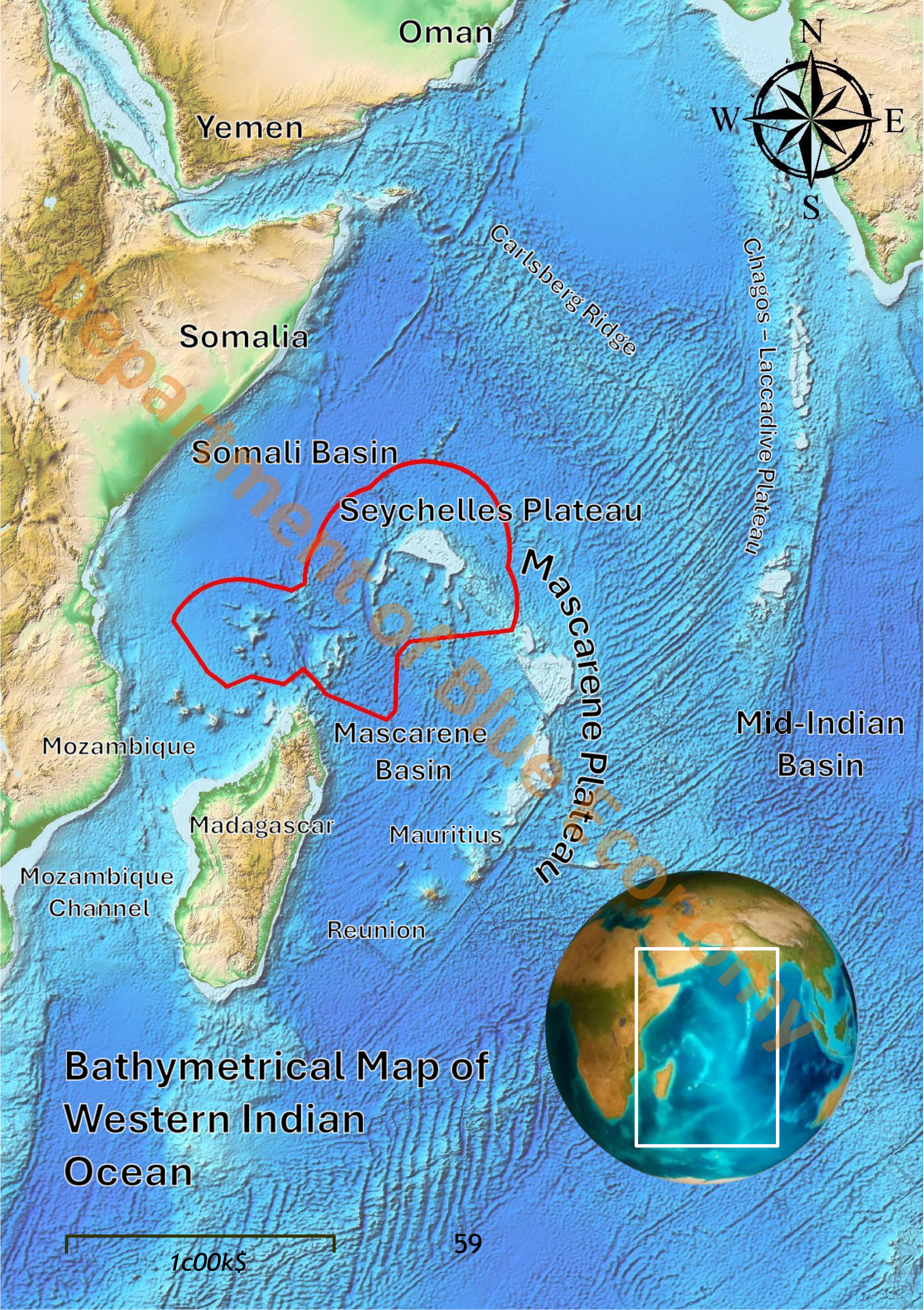
Siliciclastic: Sediments composed mainly of silicate minerals, mainly formed within continental crusts.

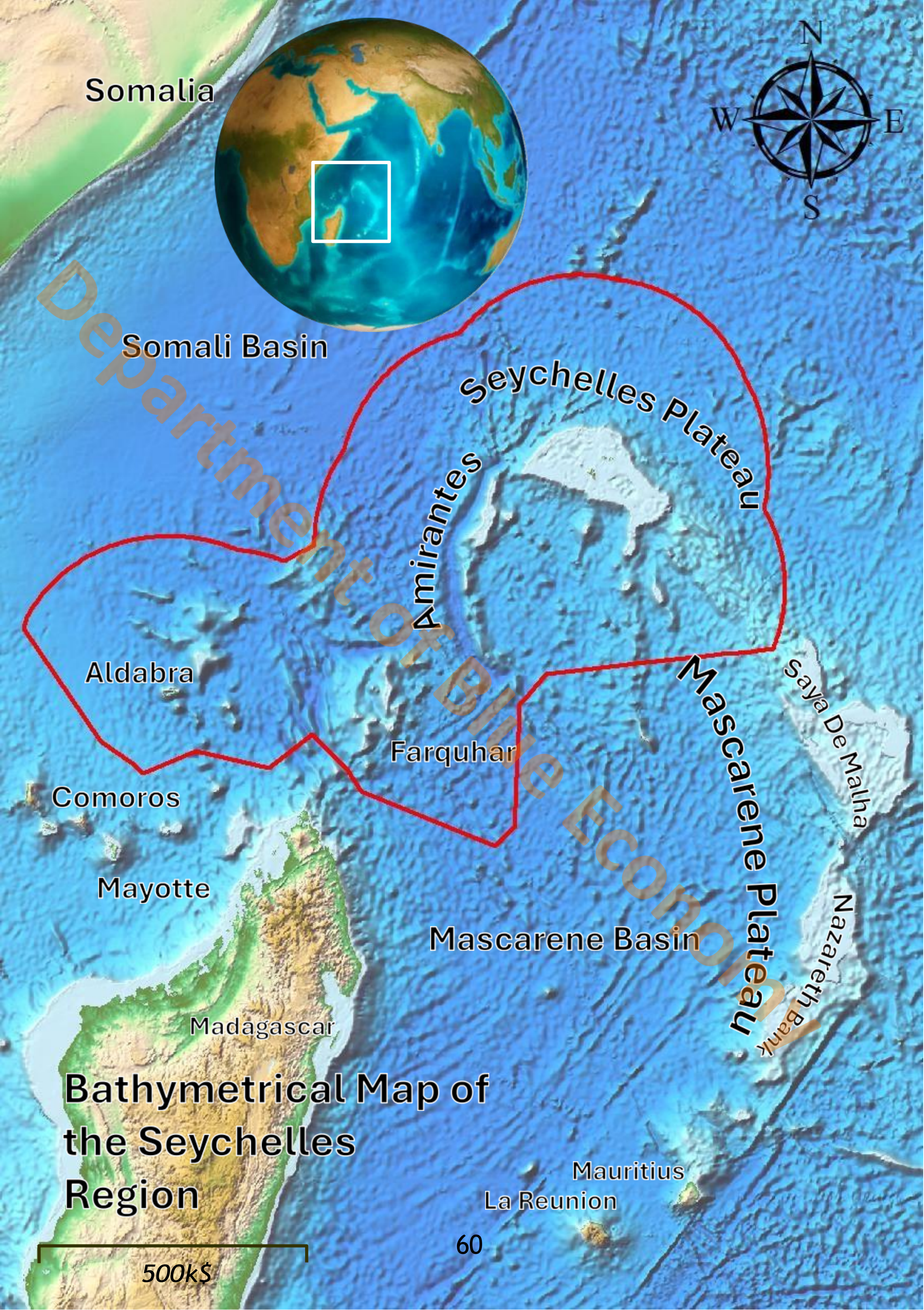
Siltstone: A sedimentary rock with fine grains between clay and sand in size.

Strata: Layers of sedimentary rock.

Subduction: The process where one tectonic plate moves under another.

Tholeiite: A type of basaltic rock found in oceanic crust and volcanic regions
Vuggy: Rock texture with small cavities, often filled with crystals.


Bathymetrical Map of Western Indian Ocean
N
W
E
S
Oman
Yemen
Somalia
Somali Basin
Carlsberg Ridge
Chagos – Laccadive Plateau
Seychelles Plateau
Mascarene Plateau
Mid-Indian Basin
Mozambique
Mascarene Basin
Madagascar
Mauritius
Mozambique Channel
Reunion
Department of Blue Economy


N
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Somalia
Somali Basin
Seychelles Plateau
Amirantes
Aldabra
Farquhar
Comoros
Mayotte
Mascarene Plateau
Saya De Malha
Nazareth Bank
Mascarene Basin
Madagascar
Mauritius
La Reunion
Bathymetrical Map of the Seychelles Region
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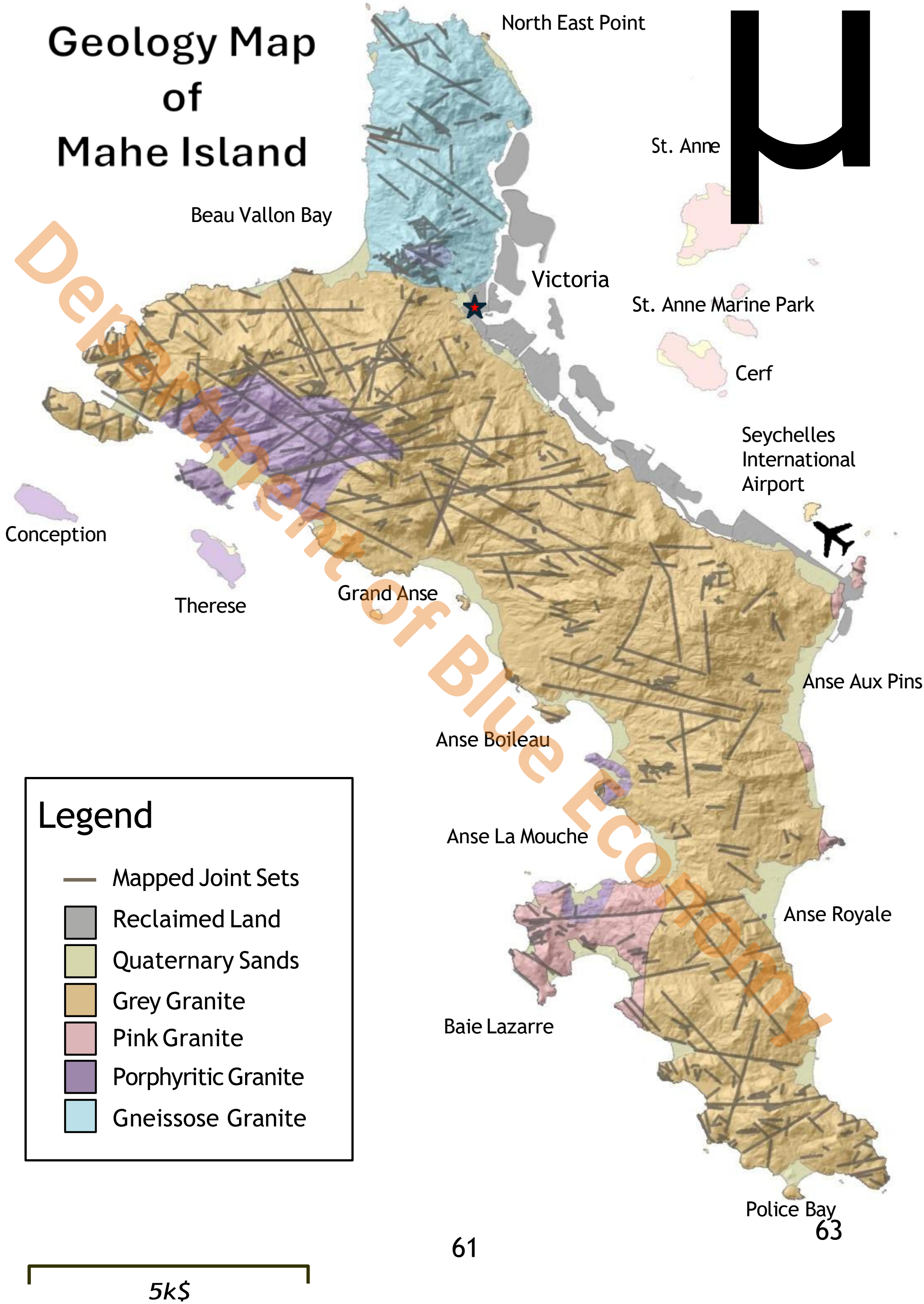
Geology Map
of
Mahe Island
North East Point
St. Anne
Beau Vallon Bay
Victoria
St. Anne Marine Park
Cerf
Seychelles
International
Airport
Conception
Therese
Grand Anse
Anse Aux Pins
Anse Boileau
Anse La Mouche
Anse Royale
Baie Lazarre
Police Bay
63
Legend
Mapped Joint Sets
Reclaimed Land
Quaternary Sands
Grey Granite
Pink Granite
Porphyritic Granite
Gneissose Granite
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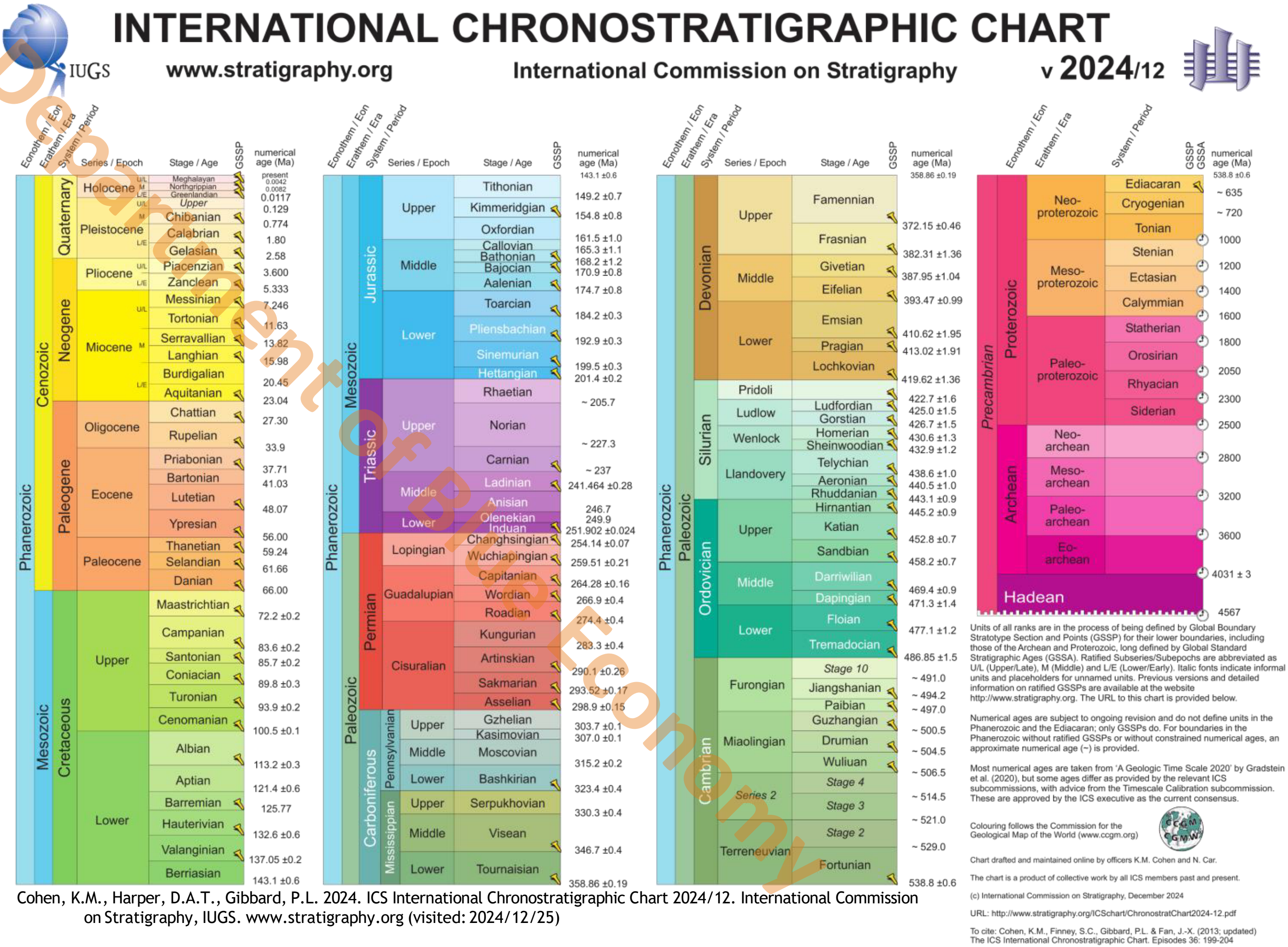
Department of Blue Economy



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