Intracontinental Tectonics and Orogeny

Intracontinental Tectonics and Orogeny

By

Yu Wang

Cambridge Scholars Publishing

Intracontinental Tectonics and Orogeny

By Yu Wang

This book first published 2025

Cambridge Scholars Publishing

Lady Stephenson Library, Newcastle upon Tyne, NE6 2PA, UK

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

ISBN: 978-1-0364-4558-4
ISBN (Ebook): 978-1-0364-4559-1

TABLE OF CONTENTS

PREFACE

The evolution of the Earth, including the formation and dynamics of global tectonics, mantle flow, and the development of both oceanic and continental crust, has been a central concern for geologists over the past two centuries. In the early 20th century, the Geosyncline-Platform hypothesis dominated the field. However, since the 1960s, plate tectonics has emerged as the prevailing theory, significantly influencing our understanding of geological processes. Currently, plate tectonics is often considered the primary framework for explaining the Earth's geological activity.

Despite its successes, plate tectonics alone does not address all aspects of global tectonics and Earth's evolution. Key issues remain unresolved, particularly regarding mantle flow, supercontinental assembly and breakup, and continental construction and destruction. Although plate tectonics is effective in explaining many phenomena, it primarily focuses on oceanic areas and continental margins, such as subduction zones and collision boundaries. This approach does not fully encompass the complexities of continental deformation and evolution.

Several significant questions remain unanswered by the plate tectonics theory:

1. **Non-Rigid Bodies:** Plate tectonics is based on the concept of rigid lithospheric plates. What about the behavior of non-rigid continental or oceanic bodies?
2. **Supercontinent Dynamics:** What are the processes and consequences of continental deformation, evolution, and mantle reworking before and after the formation of supercontinents?
3. **Transitional Lithospheres:** How do features and processes from continental to oceanic lithospheres, or from orogeny to post-orogeny and from initial rifting to oceanic ridges, influence plate divergence and convergence?

4. **Continental Margin Processes:** How does plate tectonics operate at continental margins, and what is its relationship to continental deformation, including spatial and temporal constraints?
5. **Mantle Flow and Dynamics:** While plate tectonics addresses convection along subduction zones, what about the evolution and dynamic constraints of the entire mantle system, and its impact on continents and plates?
6. **Vertical Motion and Tectonics:** Plate tectonics emphasizes horizontal motion and stress. However, vertical motion, intraplate orogeny, and intracontinental tectonics are not fully explained by this framework.
7. **Mass Extinctions:** The mechanisms behind mass extinctions, often attributed to volcanic eruptions or mantle plumes, remain unclear. What role do continental interiors and tectonic processes play?
8. **Stress Transmission:** How is stress transmitted within continents, especially in cases of intracontinental tectonics? Are there specific mediums, such as viscous or plastic channels, that facilitate this stress transmission?

These unresolved questions highlight the limitations of plate tectonics and underscore the need for a more comprehensive understanding of global tectonics and Earth's evolution. Further research is essential to address these issues and to develop a more complete picture of our planet's dynamic processes.

Global tectonics encompasses both plate tectonics, which deals with the rigid lithosphere, and intracontinental (or intraplate) tectonics, which involves the non-rigid aspects of the lithosphere. To fully understand Earth’s tectonic processes, it is beneficial to integrate these two perspectives into a comprehensive framework. Thus, we propose the term "transcontinental tectonics" to represent the sum of plate tectonics and intracontinental tectonics, defining global tectonics as:

Global Tectonics = Transcontinental Tectonics = Plate Tectonics + Intracontinental Tectonics

Studying intracontinental tectonics provides crucial insights into tectonic processes that are not fully explained by plate tectonics alone. It enhances our understanding of various geological phenomena, including:

- **Intracontinental Orogeny:** Investigating orogenic processes within continents improves our knowledge of continental deformation and evolution.
- **Earthquakes and Volcanic Activity:** A better grasp of intracontinental tectonics can lead to improved earthquake forecasts and volcanic investigations.
- **Climate and Environmental Changes:** Understanding tectonic processes helps explain the evolution and episodes of Earth's climate changes, providing insights into how geological and environmental conditions are interlinked.
- **Resource Exploration:** Knowledge of tectonic processes can guide the exploration of energy and mineral resources.
- **Geological Conditions:** Studying non-rigid blocks and tectonic belts enhances our understanding of stress, fluid dynamics, temperature, and pressure variations within the Earth.

Advancements in analytical techniques and technologies will further our ability to explore and understand these complex processes. By integrating plate tectonics with intracontinental tectonics, we can develop a more holistic view of Earth's geological evolution and address the unresolved questions that remain in the field of global tectonics.

As a new field of study, the highlights of this book on "Intracontinental Tectonics and Orogeny" are as follows:

1. **New Tectonic Terms:** While plate tectonics has been the dominant framework for understanding continental margins, recent studies in intracontinental tectonics have introduced new terms to describe phenomena such as intracontinental superimposed tectonics, layered-horizontal shear, layered-crustal rotation, and intracontinental superimposed basins. These terms enhance our understanding of compression, extension, and strike-slip motions within continents

and contribute to global tectonics, particularly in the context of energy resources and seismic forecasting.

2. **Linkages between Plates and Continental Deformation:** Traditional studies have primarily focused on far-field stress release, but recent research highlights the direct pathways of stress transformation and transmission from continental margins to continental interiors. This includes how stress from subduction and collision belts influences intracontinental areas. The study also addresses how lost subduction signals, such as ophiolites and blueschists, can be inferred from intracontinental erosion, deformation, and sedimentation patterns, providing insights into potential subduction events and their characteristics.
3. **Challenges in Intracontinental Orogeny Classification:** Existing geological frameworks based on plate tectonics have often overlooked orogeny within intracontinental settings. This book explores various orogenic belts that lack clear subduction or collision indicators, such as the Cenozoic Tianshan in China and the Pyrenees in Europe. These findings challenge traditional classifications and offer a more nuanced understanding of orogenic processes and their implications for global tectonics.
4. **Intracontinental Tectonics by Compression, Extension, and Shear:** Beyond the classic plate tectonics framework, this study investigates new structures formed by long-term compression, extension, and shear within intracontinental regions. It explores the formation of structures around tectonic blocks, basins, and crustal layers, including co-axial and non-co-axial superimposed tectonics. The research also examines the effects of multiple compressions and interactions between different tectonic units, revealing new types of tectonic formations such as arch-continent and mantle extrusion.
5. **Non-Unique Effects of Tectonic Units:** The study emphasizes the complex roles of continental texture, framework, and composition in tectonic processes. Unlike oceanic lithosphere, the layered crust

and mantle in continental settings exhibit unique shear behaviors. The influence of weakened zones, inherited structures, and transitional lithosphere plays a crucial role in guiding the evolution of tectonic systems. This research highlights how these factors contribute to the formation of different tectonic frameworks and their implications for both intracontinental and plate tectonics.

6. **Intracontinental Volcanic Eruptions and Earthquakes:** While much of the geological focus has been on volcanic eruptions and earthquakes in tectonic margins, the impact of intraplate volcanic eruptions and earthquakes is significant for human populations and their environments. Despite progress in studying intraplate earthquakes, the mechanisms and distribution remain less understood compared to margin-related earthquakes. Factors such as reworking, weakened zones, and far-field stress release from continental margins need further exploration. Elastic and plastic deformations related to earthquakes should be considered, and the differences in mantle flow types between continental settings and subduction zones must be examined. Understanding the vertical and oblique mantle upwelling and its link to volcanic eruptions and earthquakes is crucial for a comprehensive view of intraplate tectonics.
7. **Intracontinental Climate Changes and Their Linkages to Tectonics and Orogeny:** While much attention has been given to oceanic changes and global climate shifts, intracontinental tectonics can significantly affect local and regional climates. Uplifted mountains, basin depressions, and mountain collapses all contribute to climate variations. The formation and erosion of mountains and river systems influence climate both in the short and long term. This area of study has not been thoroughly explored within the framework of plate tectonics, which traditionally focuses on subduction and mantle wedge interactions. Investigating how past continental tectonics and mantle dynamics relate to

climate events, such as the Great Oxidation Event, could provide new insights.

8. **New Hypotheses on Mantle Dynamics and Their Impact on Plate and Continental Tectonics:** Mantle dynamics have long been a focus of geological research, but traditional models primarily emphasize convection in one or two layers. Recent studies suggest that mantle advection, along with horizontal and vertical flow patterns, plays a significant role. This includes shear zones and mantle extrusion beneath continents. Understanding these dynamics, including rotated mantle flow and energy transmission around the continental lithospheric root, could provide new perspectives on tectonic processes.
9. **Transcontinental Tectonics Beyond Plate Tectonics:** Plate tectonics focuses on rigid lithospheres and their movements over the asthenosphere. However, this framework does not fully address the evolution of continents and their interactions. Transcontinental tectonics, which includes both plate tectonics and intracontinental tectonics, offers a more comprehensive understanding. By incorporating both rigid and non-rigid elements, this approach seeks to resolve gaps in our understanding of global tectonics and Earth evolution.

Acknowledgments: Financial support for this research was provided by the China University of Geosciences (Beijing), the Chinese National Science Foundation (NSF), the State Key Laboratory of Geology and Mineral Resources, the Innovation Center of Front Geology, and Key Laboratory of Intraplate Volcanoes and Earthquakes. Special thanks are due to Profs. Jishun Ren, Zhaohua Luo, Tiannan Yang, Shaofeng Liu, Tianfeng Wan, Ben van der Pluijm, Dengfa He, Lixin Sun, Ben Holdsworth, Tim Kusky, Yunpeng Dong, Shuwei Guan, Hongyi Li, Jinli Huang and Liang Qiu for their valuable discussions and contributions. Drs. Shuzhi Wang, Junyi Sun, and Jiawei Cui played crucial roles in diagram preparation and data collection, respectively. I would like to express my sincere gratitude to

Herui Wang for her invaluable assistance in the final preparation of this book. Her careful proofreading and insightful suggestions greatly improved the clarity and precision of the text.

Yu Wang
CUGB

CHAPTER 1

INTRODUCTION

Over the past 200 years of geologic advancement, tectonic theory has evolved significantly. Early hypotheses ranged from the Earth contraction and expansion theories to the Hydrological theory, proposed by Abraham Gottlob Werner, and the Igneous theory by James Hutton. This progression continued with the Geosyncline-Platform theory, attributed to the works of James Hall, James Dwight Dana, and Eduard Suess. Even when the Geosyncline-Platform hypothesis was applied to China, it paved the way for the development of distinct tectonic hypotheses such as Block tectonics, Multiple-cycle reactivation, and Platform reactivation during the 1950s-1970s. Following the introduction of Wegener's Continental Drift theory, the modern understanding of plate tectonics emerged, and later, theories beyond plate tectonics, such as transcontinental tectonics, have been developed. Despite these advancements, global tectonics continues to be fundamentally based on the plate tectonics theory.

While plate tectonics remains the cornerstone of current tectonic understanding, unresolved issues persist. These include the complexities of shear tectonics and mantle flow dynamics, which challenge the notion that plate tectonics alone can fully explain the Earth's tectonic behavior, particularly concerning continental plates. The plate tectonics theory, though robust, does not encompass all dynamic processes, such as mantle convection and the disparities between oceanic and continental lithospheres. Critical questions, such as the mechanisms behind the initiation of plate tectonics, continental loss, and the fragmentation of supercontinents, remain only partially answered.

As the plate tectonics theory continues to evolve, attention must be paid to emerging concepts like mantle dynamics, continental textures, and basin deformation, especially in intracontinental regions. New terminology and unresolved issues are being introduced to refine our understanding of modern tectonics. Key concepts include extensional high-temperature metamorphism, decompression magmatism, and the interaction of extensional tectonics within compressional regimes, as well as the coexistence of extensional and contractional tectonics.

Furthermore, when considering subduction processes, it is evident that continental plates do not behave as rigid bodies, particularly in intracontinental settings. The interplay between oceanic plate subduction and continental deformation is complex and critical to the understanding of orogeny and intracontinental tectonics. Intracontinental subduction, collision, and block convergence within continental interiors—processes that fall outside the framework of traditional plate tectonics—are pivotal to global tectonics. During the formation and subsequent breakup of supercontinents, factors such as continental deformation, weakened zones, inherited structures, and transitional lithosphere and tectonic units must also be considered.

The focus of this book is on intracontinental tectonics and orogeny, as well as deformation, magmatism, metamorphism, and rift sedimentation in non-plate tectonic settings. Supercontinents, while often viewed as transient or jigsaw-like formations, present unresolved challenges. For instance, the origin of rifting and the reasons behind continental float remain unclear. Questions arise concerning the behavior of supercontinents during their assembly or breakup, and why orogenic belts like the Qinling orogenic belt in China experienced repeated subduction or collision events at the same geographical location. These complexities cannot be fully explained by traditional plate tectonics alone. Instead, a broader understanding that incorporates intracontinental and transcontinental tectonics—underpinned by global mantle flow—may offer solutions to these questions.

1.1 Traditional terminology of tectonics and development

Tectonics has traditionally been categorized into global tectonics, plate tectonics, intraplate tectonics, or intracontinental tectonics. The conventional terminology in tectonics is primarily rooted in the processes of compression, extension, and shear stresses, as well as their various combinations. These terms are largely derived from geosyncline theory or plate tectonics and are typically applied to the plate boundaries or continental margins. However, these traditional concepts are insufficient for outlining the complexities of intracontinental tectonic evolution and development.

While plate tectonic orogeny and intracontinental orogeny may appear to share similar terminology, they differ significantly in terms of their tectonic settings, basement structures, materials involved, tectonic stresses, and kinematic processes. These differences highlight the nuanced nature of intracontinental tectonics, which cannot be fully understood through the lens of traditional plate tectonics terminology alone.

In the case of the Basin and Range Province, the formation of basins and ranges occurs simultaneously, yet these structures are not directly related to mountain-building processes associated with compression. Instead, they are more indicative of extensional tectonics or flexural responses and can be classified as "basin-in-mountains" structures. These features often resemble metamorphic core complexes, where shear tectonics plays a significant role in their development. This distinction emphasizes the need for a refined understanding of the tectonic processes occurring within continental interiors, as they are not easily explained by the traditional framework of plate tectonics.

1.2 Geosyncline theory and orogeny

In the early to mid-20th century, the Geosyncline-Platform hypothesis emerged as the dominant theory to explain Earth's tectonic evolution, particularly that of continental tectonics. This hypothesis has been extensively detailed in numerous geological texts. In 1843 and 1856, H. D. Rogers and W. B. Rogers proposed that the Appalachian Mountains in the United States were a geosyncline, suggesting that their uplift was caused by gas trapped beneath the Earth's surface, which eventually exploded. In 1859, James Hall described the Appalachian Mountains as a typical sedimentary formation that could evolve into an orogenic belt. By 1873, James Dwight Dana introduced the term "geosyncline" and linked it to the theory of Earth's contraction as a mechanism for mountain-building. In 1885, the Austrian geologist Eduard Suess referenced "terranes" in the crust, noting their stability—an idea later applied to regions such as Sino-Korea, Russia, Siberia, North America, and the Canadian Shield.

The core tenet of the geosyncline theory centers on the formation of orogenic belts. It posits that continents can fragment, accumulate sediments in specific locations under vertical stress, and eventually undergo folding, thrusting, metamorphism, and magmatism to form orogenic belts. Sedimentation along continental margins was divided into miogeosynclines and eugeosynclines, terms analogous to the active and passive continental margins seen in plate tectonics.

The Geosyncline-Platform theory emphasized vertical movement as the primary driver of crustal activity, with uplift and subsidence creating oscillatory motions. Horizontal tectonic stresses were considered secondary or derivative. According to this model, crustal dynamics were largely governed by gravitational forces, where upwelling of mantle materials caused subsidence, and downwelling led to uplift. The geosyncline and platform were regarded as the primary tectonic units, with orogeny resulting from the closing of geosynclines and the subsequent erosion that formed platforms.

Geosynclinal belts were viewed as the most active and deformed zones of the continental crust, comparable to intracontinental rift systems. Initially, these areas experienced subsidence and the accumulation of thick sedimentary layers, accompanied by mafic and ultramafic magmatism. Sediment deposition typically transitioned from coarse to fine-grained materials, ranging from sandstone to claystone, dolomite, and limestone.

Subsequent compression, uplift, deformation, and acid magmatism, along with partial metamorphism, led to extensive folding and thrusting. These processes were followed by the deposition of molasse-type sediments. Large-scale tectonic events, marked by compression and uplift, gave rise to mountain ranges that were later subjected to long-term erosion, eventually forming flat, stable surfaces. This stage, akin to cratonization, healed faults and fractures, transforming the crust into a solid, rigid block.

Terranes, in contrast, were characterized by limited deformation, with thick sedimentary layers covering older folded and metamorphic rocks that formed the crystalline basement. If erosion exposed these layers, ancient crustal segments (often older than 3.0 Ga) would be revealed as shields, while relict continental fragments became cratons. The Geosyncline-Platform hypothesis focused on crustal deformation and development, with orogeny being seen as the active phase of a geosyncline. The processes of compression, uplift, collapse, and erosion formed orogenic belts, which were theorized to develop in the same location as the original geosyncline.

However, unlike plate tectonics, which involves large-scale horizontal movements of lithospheric plates, the Geosyncline-Platform theory suggested that crustal and mantle interactions were largely static, with little horizontal motion. The theory lacked an explanation for oceanic tectonics, oceanic crust formation, and evolution, focusing solely on the vertical dynamics of the continental crust. The platform and geosyncline were viewed as two distinct crustal features—stable and active—but the theory failed to adequately address the global tectonic system, particularly the relationship between oceanic and continental crusts, and the concept of lost continental fragments submerged beneath the oceans. Additionally, it did not account for the long-term activity of certain tectonic belts or the large-scale stability of certain regions of the Earth's crust.

The tectonic evolution described by the Geosyncline-Platform hypothesis involves four main stages, which are similar to the formation of modern orogenic belts between converging continents:

1. **Strong Deposition and Rift Formation:** Characterized by significant subsidence and sediment accumulation, often accompanied by basaltic eruptions in intracontinental rift systems.
2. **Uplift and Folding:** Formation of linear folds through compression, with subsequent granitic intrusion and metamorphism.
3. **Mountain Uplift and Orogenic Development:** Continued compression leading to mountain uplift and the formation of the orogenic belt, with deformation propagating into the foreland.
4. **Collapse and Erosion:** The collapse of the orogenic belt, followed by erosion and the deposition of molasse-type sediments, signaling the end of the orogenic process.

The Geosyncline-Platform hypothesis posits a static model for crustal and mantle interactions, wherein there is no large-scale horizontal motion between the crust and lithosphere or between the mantle and lithosphere. This hypothesis is grounded in the study of continental crust, thus omitting considerations of oceanic floor processes and their evolutionary dynamics. Consequently, the hypothesis does not account for oceanic tectonics, the formation and evolution of oceanic crust, or the comprehensive dynamics of oceanic crustal development.

The model categorizes crustal features into two types: stable platforms and active geosynclines. However, it falls short in fully describing the global crustal system, including both continental and oceanic crusts, as well as the submerged continental fragments beneath the ocean and the transitional crusts between oceanic and continental domains. The Geosyncline-Platform hypothesis primarily addresses vertical motions and does not accommodate the complexities of horizontal tectonic processes. Additionally, it lacks an explanation for the persistence of long-term tectonic belts and the extensive stability of certain crustal regions.

1.3 Plate tectonics

In 1912, Wegener (1912a, b) introduced the hypothesis of continental drift, proposing that continents were once joined and have since drifted apart. He noted that geological and fossil similarities on both sides of the Atlantic suggested a historical connection between the continents, which later led to the concept of continental break-up and separation. However, Wegener's hypothesis lacked a detailed mechanism or dynamic explanation for this movement.

In the early 1960s, significant advancements were made in understanding the mechanisms behind plate tectonics. Hess (1960) and Dietz (1961) introduced the concept of oceanic-floor spreading, which Hess (1962) further developed and supported with paleomagnetic, chronological, oceanographic, and geophysical data. According to this theory, the oceanic floor is formed at mid-ocean ridges where asthenospheric upwelling creates new rock and lava. This process causes the oceanic floor to spread laterally away from the ridge, leading to the formation of new oceanic crust. As new crust is created, older oceanic crust is subducted beneath continental plates or other oceanic plates, where it is eventually melted in the mantle.

The development of plate tectonics as a formal hypothesis began to take shape between 1963 and 1966. Vine and Matthews (1963) provided evidence supporting the theory of oceanic ridge spreading, which helped establish the foundation of plate tectonics. By 1967-1968, Mckenzie and Parker (1967), Morgan (1968), and Le Pichon (1968) independently and collaboratively refined the concept into the modern theory of plate tectonics (Figure 1-1). This theory posits that the Earth's lithosphere is divided into rigid plates that float and move on the semi-fluid asthenosphere beneath them. These plates can break apart and reassemble into various configurations, leading to the classification of major tectonic plates. Initially, six major plates were identified, but further research has expanded this classification. The evolution of plate tectonics from Wegener's continental drift hypothesis to its current form represents a significant advancement in understanding Earth's dynamic processes.

When the oceanic crust approaches a continental margin, it undergoes subduction and is eventually lost into the mantle. Along the subduction zone, the descending slab creates either a broad or narrow oceanic trench. As the subducted oceanic crust melts in the mantle, volcanic activity on the continental margin leads to the formation of an island arc. The process of underthrusting and shearing often leaves remnants of the oceanic crust, known as ophiolites, which are preserved as part of a mélange that includes oceanic and trench sediments such as sandstone and claystone.

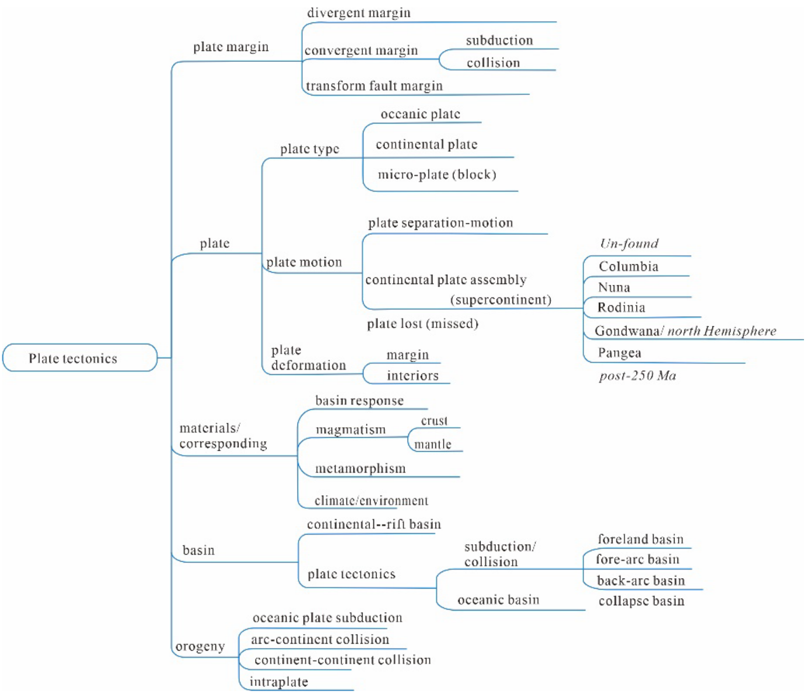

Figure 1-1 Plate tectonics and its subjects.

Following subduction, the formation of fore-arc and back-arc basins is observed. These basins display rift-related deformation and sedimentation in a compressional environment. The obduction of oceanic crust onto the continental margin contributes to mountain building and orogenic belt formation. This mountain-building process involves the compression of the continental margin, incorporation of arc-island materials, and subsequent uplift. Erosion and continental collision can further expose subduction-related metamorphic rocks and lower crust-upper mantle materials on the Earth's surface.

In the continental realm, sedimentation and compression propagate inward, forming foreland basins. As tectonic processes conclude, gravitational collapse and mantle flow can cause these regions to transition from a downward state to a flatter configuration. These general features have been well-studied and are referenced here to facilitate a comparison with intracontinental orogeny and plate tectonics.

Oceanic crust tectonics are closely linked to mantle convection processes. The oceanic crust, as the upper part of the mantle convection system, forms at mid-ocean ridges and subsequently moves downward towards subduction zones or convergence areas. Mid-ocean ridges represent regions of mantle upwelling driven by convection, while oceanic trenches signify areas of downwelling and material return within the mantle.

1.4 Plate tectonics: Can it be or not be?

Plate tectonics is predicated on the concepts of continental drift and oceanic floor spreading, suggesting that Earth's surface is covered by relatively rigid, non-deforming lithospheric plates. These plates are thought to move at rates ranging from 1 cm to 10 cm per year, either in similar or differing directions. Plate boundaries are classified into three types: convergent, divergent, and transform. According to the plate tectonics theory, these plates are characterized by minimal deformation, contrasting sharply with the intraplate or intracontinental regions where deformation is prevalent and plates are considered less rigid.

This distinction presents a significant challenge: the theory of plate tectonics assumes a rigid lithosphere, but what if this assumption is not accurate? Plate tectonics has historically dominated the understanding of shallow mantle behavior, as evidenced by the Wilson Cycle record extending back over 180 million years and the subsequent plate tectonic record. Burke (2011) proposed integrating plate tectonics with the Wilson Cycle and mantle plumes from the core-mantle boundary (CMB) to develop an enhanced geodynamic model of mantle behavior. However, current geodynamic models have yet to fully incorporate these recent observations, leaving the question of whether plate tectonics alone can adequately explain mantle dynamics and surface processes.

1.4.1 Plate tectonics: dynamics and classification

Plate tectonics encompasses the concept that Earth's lithosphere is segmented into various rigid continental and oceanic plates, which float on the underlying, more fluid asthenosphere. This movement is driven by mantle convection processes (Cook and Varsek, 1994; Torsvik et al., 2008; Cawood et al., 2022). While mantle convection primarily influences oceanic lithosphere and crust, the movement of continental plates and microplates is also influenced by mantle advection or horizontal mantle flow. These plates move horizontally in various directions and can only stop or change direction when interacting with other continents, leading to subduction or collision events. When combined, these plates can form supercontinents. A key question remains whether these supercontinents continue to move or if they have ceased motion, as no definitive answers exist. The mantle upwelling, driven by mantle plumes, can lead to the breakup of supercontinents, initiating new cycles of plate tectonics (Wilson, 1965, 1973; Kusky et al., 2010; Santosh et al., 2010; Nance and Murphy, 2013; Faccenna et al., 2021). Currently, the major tectonic plates on Earth are the Eurasian, Pacific, American, African, Indo-Australian, and Antarctic plates. Another question is whether pre-existing weakened zones within supercontinents have facilitated the formation of these plates, or if multiple subduction-collision relicts are present in orogenic belts or continental margins.

Plate tectonics is characterized by three key hypotheses: (1) the existence of rigid lithospheric blocks, (2) the motion of these blocks, and (3)