OUR DYNAMIC EARTH AND THE LENGTH OF DAY

A Treatise On The Origin of Tectonic Forces
As Influenced by Earth’s Rotational Deceleration

New Concepts to Enable Understanding Tectonism and the Forces
Controlling Earth’s Geologic History

BY:

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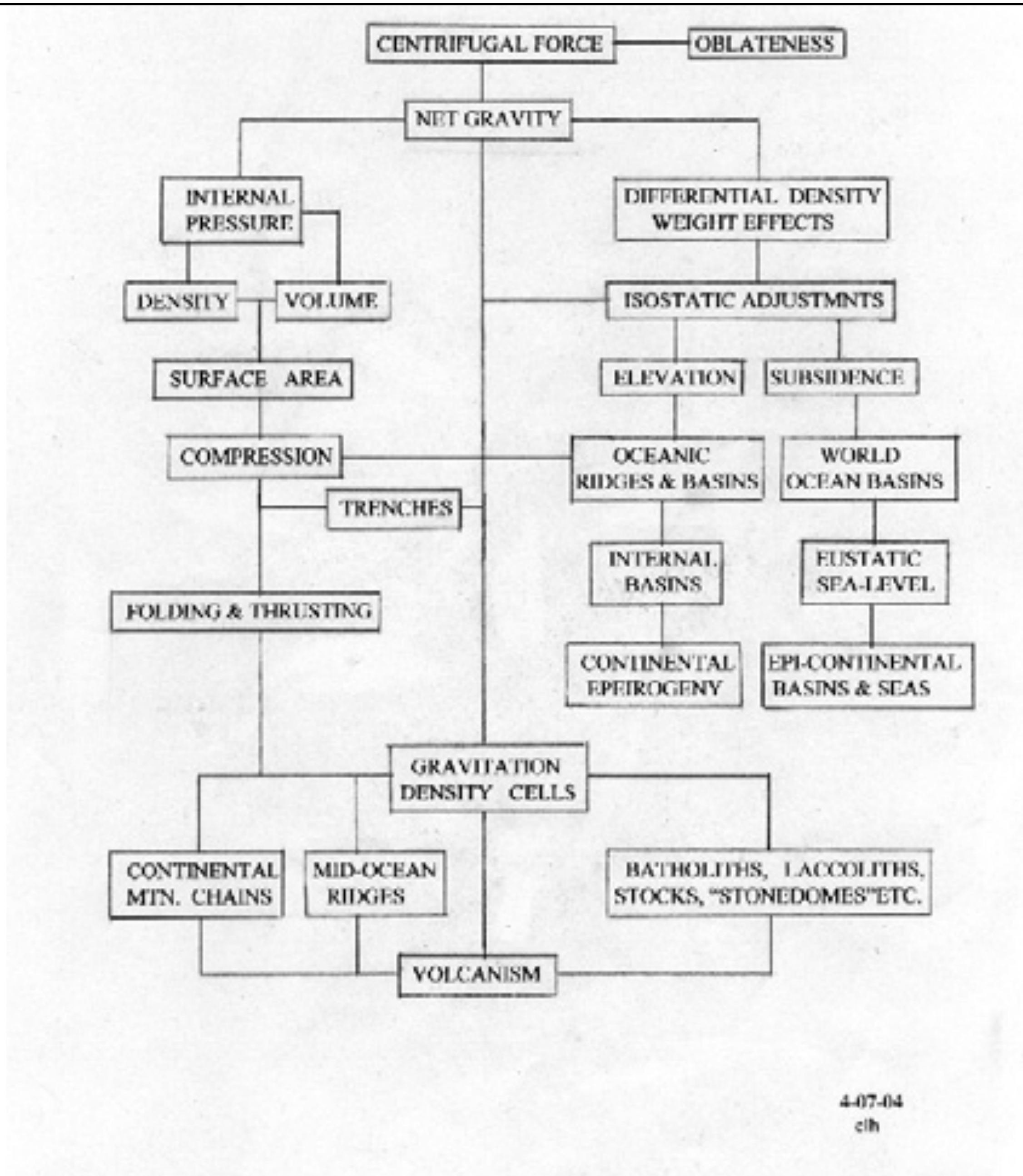
1.02 *ON PREFERRED THEORIES*

“The mind lingers with pleasure upon the facts that fall happily into the embrace of the theory, and feels a natural coldness toward all those that assume a refractory attitude. Instinctively, there is a special searching out of phenomena that support it---- The mind rapidly degenerates into the partiality of paternalism. The search for facts, the observation of phenomena and their interpretation, are all dominated by the affection for the favored theory until it appears to its author or its advocate to have been overwhelmingly established ----- A premature explanation passes first into a tentative theory, then into adapted theory, and lastly into an adopted theory.

T.C. Chamberlin (1897)
The method of Multiple working Hypotheses

EARTH DECELERATION EFFECTS

Diagram of Inter-related Effects on Crustal Dynamics



1.03 TO THE READER

The material herein represents a work in progress since around 1991. The core concepts represent the author’s own original thinking and conclusions based on a background of education and experience in geology plus practical experience in marine geophysics. The conclusions and suggestions presented are based on a combination of personal computer modeling and a study of published literature in Scripps Institution of Oceanography Library
at La Jolla, Calif.

As is true in most areas of science, the literature searches revealed
that others had visited many of the same areas of thought, and reached similar separate conclusions previously, but, no author appears to have combined the presently available knowledge into a tectonic hypothesis based on the laws of physics, knowledge of our solar system, and sound geologic principles.

A principal deterrent to past authors in reaching sound conclusions when synthesizing otherwise excellent research, was a failure to recognize the fundamental role that gravity plays in a rotationally decelerating Earth.

I firmly believe that the fundamental concepts related to the effects of gravity stemming from Earth’s deceleration will withstand all scrutiny
and lead to great advances in Earth Science.

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June 20, 2003 Carroll L. Hoyt

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"Darwin's Origin of Species "was badly received by the generation to which it was first addressed, and the outpouring of angry nonsense to which it gave rise is sad to think upon. But the present generation will probably behave just as badly if another Darwin should arise and inflict upon them that which the generality of mankind most hate---- the necessity of revising their convictions."

Thomas H. Huxley in The Life and Letters of Charles Darwin

1.05 PREFACE

Over the past two or three decades, virtually all scientific writing dealing with problems in geology and the Earth's geologic past have evolved in an environment framed within a triangle of three concepts widely accepted as paradigms:

1) Sea-floor Spreading, 2) Subduction, and 3) Continental Drift

All recent syntheses in papers on mechanisms and events in past geologic history have, thus, comported with and been styled to an acceptance of one or all three of these concepts. Whether every author was personally convinced of the validity of all aspects of these concepts, accepted them without critical thought, or, went with the flow of politically correct geologic dogma, in most cases cannot be judged.

The answer is, in fact, of no great import since nearly every paper contains (we assume) observations and data (by competent scientists) that are a contribution to the total body of knowledge in the respective field. At worst, faulty syntheses will only have delayed learning the ultimate truth, whatever that may prove to be.

Having said this, the present author feels certain that we can make only limited progress to a better understanding of Earth history by omitting and failing to consider and incorporate in our thinking, the effects of Earth deceleration based on accepted physical laws. Some of what is to follow is speculative and may be in error, still, the underlying fact of Earth's deceleration, presently and in the geologic past, can hardly be denied. A decrease in earth's rotation from an estimated ten hour day two billion years ago to the present 24 hours requires no extended scientific investigation to conceptualize the impact on every aspect of earth's environment and crustal stability. Key questions, of course, relate to the timing and actual magnitude of the changes involved. One thing is certain, if we study and interpret incomplete data though a faulty lens, it is likely we will obtain faulty answers.

I will discuss the three referenced paradigms in more detail later. But, I will offer some preliminary comments here.

First, the concept of *Continental Drift,* I believe, remains an open question. Considerable

evidence relating to faunal and floral distributions along with climatic and lithologic correlations has been offered in support of this idea. Some of it seems quite compelling.
A major drawback, at least until recent times, was the lack of a driving mechanism to move the broken pieces of Gondwana and Laurentia to the desired (interpretive) locations. The concept of sea-floor spreading equipped with crustal conveyer belts to carry away excess slabs of new crust to a subducted doom in the mantle seemed to be the answer. But, there may be another mechanism that drives errant continents.

The idea of sea-floor spreading from “mid-ocean” ridges sounds suspiciously like an *ad hoc* concept to support a drift mechanism. Of course, spreading immediately demanded a means to dispose of old crust as “new” was created. Enter stage right, the idea of subduction. Now, synthesizers had a nearly full set of tools. Only plate rotation was lacking. Someone quickly brought this on-stage.

The field for imaginative and creative thinking was now wide open. First, pluck a needed piece from a climatically and lithologically suited part of Gondwana or Laurentia (Pangea), rotate it, then send it drifting in the proper direction until it *crashed* into the desired continent and accreted (sutured) itself in place.

The technique allows a “solution” to almost any vexing geologic problem. This may sound cynical (or worse) but, that is exactly what I see in reading papers on the geologic history of South East Asia. The result is a jigsaw puzzle of numerous different small blocks “sutured” together at various times from a bountiful Pangea.

The author’s initial interest in the fundamental causes of Earth’s tectonic forces began in 1954. None of the ideas then current on this subject seemed satisfactory, and many previously published proposals had been rejected. It was generally conceded that no satisfactory answers were then available.
After graduation from the University of Washington, the practical aspects of earning a living in geology, and later in marine geophysics, terminated further serious effort in this area. An alertness for further applicable information remained with me throughout my working career until retirement. In the interim, Wegner’s (1912) hypothesis of continental drift slowly re-gained adherents. Then in the 1960s oceanographic studies led to the concepts of sea-floor spreading, and subduction, eventually being incorporated with thermal convection and magnetic stripes to comprise the over-reaching hypothesis of Plate Tectonics. These new ideas became widely accepted and eventually gave new life to Wegner’s drift hypothesis.

Several years into retirement, my interest in tectonics reasserted itself in further research of the literature and in better developing and mathematically examining my own concepts using spreadsheets and plots on a personal computer. After two intervals of intense effort I laid the work aside for a time, convinced that the fundamental concepts were right. But, there remained many loose ends.

Additional work demanded a more detailed review of literature to answer the following:

1) Can the extensive work of others be utilized to improve and expand critical aspects of

my fundamental concepts?

2) What are the weaknesses and faults in currently accepted geological and physical paradigms on which interpretive syntheses are based?

3) Will they tie together the vast array of isolated facts about Earth history in specialized fields and enable the stated opinions of other authors to be linked to new hypothetical concepts?

4) Will these ideas be a step forward to a better understanding of the evolution and history of our planet Earth?

I believed that all of these questions could be answered affirmatively. Further research and study slowly developed and solidified a hypothesis that fit the laws of physics and seemed conformable to our present understanding of geology, physics, paleontology, and the Earth's long and diverse geologic history.

Not too surprisingly, research revealed that many of the disparate elements critical to my ideas had been proposed by other writers in the past. Many of these discussions were scattered in time and in broadly diverse publications. Unfortunately, none were linked into an integrated comprehensive fundamental hypothesis.

My objective was to identify Earth's basic tectonic mechanisms that were a source of energy for the immense force required to uplift continents, depress ocean basins, and create vast linear belts of faulted and folded mountains.

The mechanisms and processes offered in this book are consonant with what we understand about geologic history, the evolution (and extinction) of life, and the Earth as a member planet in our solar system. In sum, this hypothesis can "stand alone" independent of unproven subsidiary hypotheses upon which plate tectonics depends to provide a sequentially whole workable tectonic mechanism. It provides a solid foundation upon which the mechanisms and geologic results we observe, can rest and be depended on.

These integrated concepts are fundamental to an understanding of Earth's tectonic history. I could not (and can not) understand how the proposed concepts can be ignored and still enable geologic historians to develop valid insights into the Earth's past. Moreover, I could not understand why other earth scientists have previously overlooked the significance of the Earth's rotationally dynamic past, its relationship to the Moon, the Sun, and the effects of slowing rotation on nearly all aspects of the Earth's outer surface, its environment and its inhabitants.

As evidence was discovered and extracted from the literature to support and add detail to my own work, it became clear that a major obstacle to the acceptance of these concepts was, in fact, a "Great Wall" that obstructed and limited further progress in understanding Earth history. That wall can be described in three words: "Plate Tectonic Theory."
The elements upon which the plate tectonics hypothesis rests and depends are pervasive. There

are diagrams depicting convection cells; mid-ocean ridges; “spreading centers”; and “conveyer belts” carrying excess oceanic crust to the maws of subduction trenches. They are found in textbooks, countless published papers, and shown in slide shows. These images are found also in the minds of young (and not so young) geologists and other earth scientists. The whole of it is then painted over and decorated with elusive magnetic “zebra’” stripes said to date the age and rate of oceanic crustal spreading.

It is not the primary purpose of this book to argue and present evidence against Plate Tectonics. That, I discovered has been ably pursued by others (discussed later). Much of that evidence consists of separate gems of fact disbursed in different scientific publications over a period of three decades. Nor, have contrary opinions been broadly accepted, due largely to the absence of alternative explanations. The aim of this book is to present an alternative set of concepts that will enable us to better understand and give answers to myriad questions not answerable by the tenets of Plate Tectonics.

My early doubts about Plate Tectonics centered on mantle convection currents, sea-floor spreading, and subduction. As my work progressed, these doubts increased and ultimately led to a belief that the “theory” of Plate Tectonics espoused by earth “mobilists” is a fiction.

The concept of plate tectonics stands on the following inter-related legs which constitute the multiple basic steps of the theoretical process. This represents a chain of events in which if one concept is not valid, the entire chain is nullified, thereby collapsing the entire theory.

These are the principal elements:

1) Thermal convection plumes rise from the mantle to create—
2) Long ridge-like spreading centers where extruded magma forms new oceanic crust.
3) Newly formed crust at spreading centers is carried away from ridges in both directions on sub-crustal currents of magma.
4) Repeated polarity reversals of polar magnetism create magnetic stripes by which the crust is dated, enabling measured of rates of motion.
5) Aging oceanic crust is carried to deep trenches where it is “subducted” deep into the mantle for recycling.
6) Movement of oceanic crust from spreading centers “explains” the force causing continental drift.

This author has often contemplated the months, the years, indeed, the entire careers of individuals who have labored on gathering data on Earth history, then organizing and interpreting these data to play in consonance with orchestrated paradigms in current vogue----- paradigms originally constructed *ad hoc* as hypothesis, but, all too soon accepted as factual. Such research, much of it of excellent quality, has gleaned troves of factual data. The difficulty arose in the interpretations that were based on faulty hypotheses.

As will be later discussed there is a great lack of strong evidence to support Plate Tectonic concepts provided by a rational understanding of the mechanisms involved, and how these mechanisms would impact and create the apparent results observed.

Peeping through between the lines of some authors are visages reflecting a doubt of the validity of certain aspects of these paradigms, but, few make clear direct statements of confrontation. Where publishing is vital to academic careers, it is easier to, "go along and get along" without questioning the "prevailing science."

Most investigators, having been educated in a period when these paradigms dominated academic seminars have, no doubt, come to believe that, 'with the great body of published literature supportive of these concepts, it is surely correct.'

The principal attraction, or, positive aspect, (if such it can be called) of Plate Tectonics Theory, standing as it does, on the legs of mantle convection, sea-floor spreading, subduction, and possibly, continental drift, is that it has allowed investigators to "solve" almost any geologic problem by moving physical pieces of the geologic puzzle great distances through vast periods of time.

Conflicts of climate and geology evidenced in stratigraphic sequences were readily solved by shifting the pieces more rapidly, more slowly, or by postulating different periods of "togetherness" before divergence from the massive agglomerations of Pangea, Gondwana and Laurentia, as these crustal segments slowly broke camp for new "digs."

But note the logic here; in seeking common elements of geology, stratigraphy, and paleontology to demonstrate drift, there is an *a priori* assumption that Gondwana *existed* before "drift" was initiated. The common elements cited show, therefore, that "drift" *has* occurred. This simply leaves unaddressed the question of Pangea's origin. Perhaps there are other explanations to account for the similarities of geometry, geology and paleontology various authors have observed.

Little does it seem to matter that none of the mechanisms underpinning the three legs of Plate Tectonics is easily visible, well supported, or well clothed. Like the tale of the "Emperor's Clothes" much is left to imagination.

1) Mantle convection: Where is the independent evidence of convection?

2) Sea-floor Spreading: Evidence for this concept, aside from magnetic anomalies, is weak to absent. Older Paleozoic and Proterozoic rocks present along the Mid-Atlantic Ridge,
in the north Atlantic, the northwest Pacific, and elsewhere, argue against it.

3) Subduction: Probably does not happen.

4) Oceanic crustal age interpretations: Results from the Deep Sea Drilling Program intended to demonstrate "spreading" are in part questionable. Many holes reported as terminated in oceanic basement, may have bottomed in young basaltic sills.

5) Continental Drift: What is the driving force? If not driven by "spreading", how do continents move? The author views the mechanisms and magnitude of "drift" as being

problems separate from convection, spreading and subduction. We will discuss some possible answers later.

All of these elements are treated in this work. It is enough to say here that evidence speaks strongly against: a) convection currents in the mantle; b) spreading centers and; and c) subduction. The validity of significant continental drift must yet be proven.

The Last Hurdle

It is well known and appreciated that the most difficult things to sell to intelligent people are new ideas. In science particularly, it has been demonstrated repeatedly that men (and women) resist acceptance of new concepts that conflict with cherished beliefs, held perhaps, through a life-time, and upon which years of hard work and diligent effort may have been based. Galileo was nearly burned at the stake for his new idea of a solar-centric planetary system. Bishop Nicolas Copernig (Copernicus) waited until after his death for an assistant to publish his new calendar based on the same heretical idea. Mendel never lived to see his work in genetics accepted.

John Locke, a 17th century philosopher wrote:

> *"It is in man's power to content himself with the proofs that he has, if they favor the opinion that suits with his inclinations or interest, and so stop from further research."*

So it is with optimism and much trepidation, that I humbly submit to the jury of truth and science an assemblage of concepts that I hope will stimulate more research and lead to the recognition of a better truth by those who labor at understanding the Earth's evolution and history.

Respectfully,
Carroll Hoyt
11-05-01

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THE GEOLOGICAL TIME SCALE

An abbreviation of the time scale by Harland et al (1990) with a more recent estimate of the base of the Cambrian period. Numbers are dates of commencements of geological periods (millions of years ago).

Phanerozoic	Cenozoic	Quaternary	Holocene	0.01
			Pleistocene	1.64
		Tertiary	Pliocene	5.2
			Miocene	23.3
			Oligocene	35.4
			Eocene	56.5
			Paleocene	65
	Mesozoic	Cretaceous		145.6
		Jurassic		208
		Triassic		245
	Paleozoic	Permian		290
		Carboniferous		362.5
		Devonian		408.5
		Silurian		439
		Ordovician		510
		Cambrian		540
Proterozoic				2500
Archean				4000
Priscoan				

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A modern philosopher believes that the scientific game is basically endless.
He who decides one day that scientific statements do not call for any other tests,
and that they can be regarded as finally verified, retires from the game.

K.R Popper (1980)

The logic of Scientific Discovery

1.07 ABSTRACT:

Earth and the Moon are interactive partners in the Earth's geologic history. The Moon's gravity, with the Sun's assistance, causes and controls Earth's aqueous and terrestrial body tides. These tides extract energy (angular momentum) from the Earth, slowing its rotation and increasing the *length of day.*

This process has mutual effects. The Earth's tidal bulge created by the Moon transfers dynamic energy to the Moon; currently causing its average orbital radius to increase at about 3.6 to 3.8 centimeters annually. Extrapolating backward, it is readily seen that earlier in geologic time, the Moon has been closer to the Earth. When in closer orbit, Lunar induced tides would have been higher and more intense; energy extraction from Earth and its transfer to Lunar orbit greater; and the rate of slowing in Earth rotation more rapid.

The Moon's rate of recession and the number of its annual orbits were both greater in the past. As the Moon's orbit expanded, its influence on Earth tides and tidal torque (often called tidal friction), diminished. Earth and the Moon are thus, an *inter-active pair*.

It may, therefore, be reasonably inferred that earlier periods of Earth history featured more intense tides, a closer, but more rapidly receding Moon, and, most important, a shorter period in Earth's (solar day) ---- a day that slowly lengthens as the Earth's rotation diminishes.

The importance of significant reduction in the Earth's rate of rotation (increasing length of day) probably dating from back in the Archaean cannot be emphasized too strongly. Biological "clocks" based on marine fossils, and the timing of lunar and solar eclipses extrapolated into the past, make it reasonable to postulate that the Earth had days of less than 10 hours in the Proterozoic or Archaean (two to three billion years B.P.).

The work of numerous researchers based on a variety of marine "paleoclocks" supports an apparent day length of 21.9 hours in the Devonian (370 Ma B.P.) and comparably short days in other periods of the Paleozoic and Mesozoic. If these data are indicative of a generalized truth, it is incumbent upon Earth scientists to examine the probable effects that constant rotational deceleration would have on Earth's

Tectonic history, and, to determine with greater accuracy and understanding the factors related to the Earth's and the Moon's interrelated dynamic history.

The most important factor related to Earth rotation is its effect on gravity. The value of gravity expressed as an acceleration factor "g" is a function of attraction between two masses and the distance between them. On Earth, *g* (net effective gravity) is also affected by geometry (oblateness) and the Earth's rotation imposing a centrifugal force.

At the equator, *net gravity* is a combination of *static gravity* and centrifugal force (Fc). Centrifugal force is dependent upon rate of rotation, and acts in opposition to gravity. As Earth's rotation rate declines, Fc diminishes and net effective gravity increases. At higher rates of past rotation, the value of net g was substantially reduced by the subtraction of greater Fc. Earth's length of day therefore is a significant factor in the value of net g.

At the Earth's poles, the value of net g is greater than at the equator due to two factors:

1) centrifugal force at the poles reduces to zero; and 2) the distance from the surface at the poles to the Earth's center of mass, is less than at the Equator (due to oblateness).

For discussion, consider the quantitative effect on net g influenced by length of day, only for sites along the equator. As distances from the equator increase, these effects will, of course, remain applicable, only in lesser values (function of cosine of latitude).

The hypothesis proposed herein may be summarized as follows:

A) Lunar tidal torque (and that from the Sun) is causing the Earth's rotation to slow down and its day to lengthen. The present rate of slowing is .0017 second per century; or about 1.0 second in 58,800 years. This reduction in rate of rotation *increases* the weight of <u>all</u> crustal rocks in proportion to their density and Earth's geometry.

B) Projected back three billion years, Earth may have had solar day lengths as short as 4 to 6 hours. This would have profoundly affected the Earth's physical characteristics and all aspects of its environment.

C) As Earth's rotation slows, the following occur:

1) Centrifugal force decreases and net gravity "*g*" increases.
2) As gravity increases, the *weight* of Earth's lithosphere, asthenosphere, and other materials increases (weight = mass x g) as a function of density.
3) As the weight of Earth's crust, and lithosphere etc. increases, Earth's internal pressures increase.
4) Increased internal pressure causes an increase in average Earth density, and a reduction in total internal volume.
5) The reduction in total Earth volume, along with reduced oblateness (a lesser factor) both result in *reducing the Earth's surface area.*

6) Crustal materials of different density (ocean basins and continents), adjust isostatically as the value of gravity increases.

7) Influenced by isostatic adjustments, basaltic ocean basins tend to subside, while lighter granitic continental areas will subside less, hold steady, or elevate due to lateral migration of dense mobile mantle from beneath oceanic to continental areas.

8) Eustatic sea levels are affected either positively or negatively as the ocean's waters adjust to the areal geometry and changing depth of the ocean basins and the vertical motion of the continents.

9) Crustal surface adjustments occur almost continuously in a tectonic environment dominated by compression, increasing net gravity, and probably mobile plates. (i.e. drift)

These unceasing forces act in concert to modify the Earth's restless surface, and influence world climate. This has been the major factor controlling Earth's geologic history and the evolution of life. Though greatly reduced, these interrelated mechanisms continue today.

* * * *

1.10 INTRODUCTORY DISCUSSION OF NEW CONCEPTS

Earth's rotational deceleration has been a critically important factor in Earth's physical evolution. The most important aspects of deceleration are the effects of increasing gravity commensurate with a reduction in centrifugal force. Because a large part of the geologic record from Cambrian to the Present has been preserved and studied, our interest in the consequences of changing gravity falls heavily in this time period. However, gravity and the length of day (LOD) undoubtedly played an even more forceful and important role in Earth's physical processes throughout the Archean and Proterozoic.

Earth tides induced by Lunar and Solar gravity have probably been active in decelerating Earth's rotation and increasing the length of day for three billion years or longer. The present rate of deceleration—.0017 sec/century, or 1.0 sec in 58,800 yrs.— if projected to 3.0 billion yrs. gives an earth day of less than 10 hours. An increase in average rate of deceleration to .0020 sec/century, a minimal figure, would place the length of day, 3.5 billion yrs B.P., at around 4.0 hours.

A reduction in rotation (increase in LOD) affects net gravity by reducing centrifugal force as a function of latitude. Maximum influence is at the equator. Therefore, as Earth slows in rotation, the factors affected include gravity, climate, environment, crustal movements, and myriad other second and third order physical conditions and processes. Earth scientists up to the present time have discounted this truth or ignored its effects completely.

Concepts comprising the Plate Tectonics hypothesis are widely accepted, forming the foundation upon which essentially all present day investigative research is now predicated and interpreted. Plate Tectonics gives only a passing nod to the influence gravity has in the processes assumed in convection, spreading, and subduction; while the profound influence that the slow increase in *net gravity* has had on all tectonic processes is ignored. Not a word about this is found in detailed discussions of Plate Tectonics or interpretational syntheses. Those scientists supportive of continental drift may also wish to assess Earth's tidal bulge and the geometry of Lunar gravity as a possible source of force in continental drift.

Our understanding of Earth's crustal dynamics is thus missing, totally, the fundamental factor which initiates the complex inter-related sequences of physical events active in tectonics. That is like attempting to assemble a jig-saw puzzle with only 2/3 of the pieces. It is why some Plate Tectonics ideas fail to match the reality of physical observations; it is why Earth Scientists, misled by *ad hoc* explanations based on erroneous concepts in plate tectonics, have yet to construct a more supportable and integrated understanding of "how the Earth works."

In order for a reader to better understand and integrate the inter-related concepts presented in this text, a rather sharp mental re-orientation is required.

First, the entire template of relationships between convection, sea-floor spreading and subduction mated with continental drift must be set aside while considering the mechanisms proposed.

Try this as a mental experiment and you may find that with due consideration, a wholly reconstituted framework for understanding the dynamics of tectonic processes will emerge. It is essential that, initially, the concepts embodied in continental drift be separated from other aspects of plate tectonic forces.

Second, think gravity! Gravity! Gravity! The increase in gravity due to Earth's rotational deceleration resulting from negative tidal torque is key to explaining the panoply of directly related physical processes active in Earth's crustal unrest. It is triggered by the simple fact of Earth's loss of dynamic energy and slowing rotation in consort with physical laws.

This exercise does not require rejection of continental drift as a possible significant player in Earth history—only that drift be looked at as a separate factor working with many others in an overall environment of evolutionary processes.

The author has examined many models assuming a wide range of rotation rates, net gravity values, and lithic densities, extended over various periods of geologic time. This work demonstrated qualitative results, not precise quantitative values. But, in every case, the effects of gravity on weight change for specific volumes of crustal/mantle material was clearly demonstrated. The author did not pursue extended studies into details of how world-wide crustal movements might be effected since, 1.) advanced math skills are required, 2) the qualitative results are clearly demonstrated, and, 3) any competent geologist or geophysicist can easily grasp the concepts demonstrated to pursue future research.

The data presented herein clearly shows the influence an increase in gravity has on crustal

materials of different densities. While all materials within the mantle and crust increase in weight as net "g" increases (wt = mg) we should first direct our attention to the Earth's two most distinguishable features, the continental and oceanic plates. It is along the margins of contact between these crustal materials of different density and thickness that the effects of weight changes wrought by increasing gravity are so clearly displayed.

Strong clues pointing to this heritage of are found in the location and concentrated zones of earthquake epicenters, folded mountain chains, and active volcanoes along continental/oceanic plate margins. The location of deep oceanic trenches parallel to and nuzzled closely to, continental margins and island arcs in the Pacific Basin provide added evidence of weight induced reactions to gravity.

In the Atlantic and Indian Oceans, both largely devoid of trenches and coast marginal volcanoes, evidence of uniform but large scale differences in reaction to increasing gravity values takes a different form. Along margins of the Atlantic, stratigraphy and the age of sediments distributed seaward across the interface of juxtaposed continental - oceanic blocks shows that, as a general rule, since early Jurassic, the oceanic crust has subsided markedly while continental blocks have subsided very little, held stable or actually risen.

While there are always exceptions to generalized statements, it is abundantly clear, that all of the world's oceans have experienced major subsidence over broad areas. Measured subsidence of some areas since Jurassic falls within a range of a few hundred meters up to more than 5000 meters.

Data demonstrating subsidence based on the DSDP drilling program, dredging, topography, submersible observations, and seismic profiles have been reported by numerous authors cited herein. The most complete summary found was that compiled by Resanov (1978).

In general the average elevation of the world's continents above sea-level is around 1070 meters (3500 ft.), while the sea-floor has an average depth of about 3800 meters (12,400 ft.). The disparity in average elevation between the sea floor and continental margins (including shelves) is a world-wide phenomena assumed to represent a state of near isostatic equality. This condition along with the subsidence in identified areas of oceanic crust since mid-Mesozoic and continuing through Tertiary to the present absolutely demands recognition of a mechanism tied to the value of gravity. Mantle convection and sea-floor spreading fails to provide an explanation for these physical facts.

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2.0 THE EARTH-MOON SYSTEM

Earth history has long been discussed in almost complete isolation and separation from a most influential neighbor—the Moon.

The Earth in its journey around the Sun is accompanied by its single satellite, the Moon. Though small in comparison other bodies in our solar planetary system, the moon ranks sixth in size among all moons in the solar system. Moreover, it is larger and more massive compared to the Earth than is any other satellite with respect to its primary (Baker, R.H. 1951). The Earth and Moon taken together have the characteristics of a double planet.

The Earth's orbit around the Sun is, strictly speaking, the center of mass around which the two bodies revolve each lunar month. If connected together, their common *center of mass* is the point at which they would balance if placed on a giant support pivot. If their masses were equal, this point would be midway between their centers. But, the moon's mass is 1/ 81.6 that of the Earth, consequently this common center of mass is located about 2900 miles (4666 Km) from the Earth's center, or within the body of the Earth (radius 6376 Km). From this viewpoint, the Earth-Moon system could be considered "Siamese twins." (Baker, op cit)

A review of Solar System planets and their satellites reveals that our Moon is larger in *relation* to its primary than any moon orbiting the other planets. The Moon's mass is 1.23% that of Earth. No other moon, not even Jupiter's Ganymede and Callisto, or Saturn's Titan, all of which are slightly larger than our Moon are comparable in mass relative to their primary. Moreover, since the surfaces of the giant planets are not visible and have masses hundreds to thousands of times greater than their moons, we will consider only the four terrestrial planets closest to the Sun.

Mercury and Venus have no moons; and Mars' moons, Phobos and Deimos are, comparatively, tiny pebbles. That leaves the Earth-Moon system unique in the entire Solar System. It therefore, becomes important to consider how the Earth differs from the three terrestrial planets whose surfaces we can observe.

The surface of Mercury, closest to the Sun, displays thousands of impact craters, but no linear mountain chains or evidence of earth-like tectonic forces. Venus, close to Earth in size, shows evidence of volcanism, impact craters, faulting, and elevated mountainous platforms. Similarly, Mars' surface carries impact craters, old volcanoes, and faulting, plus evidence of erosion and mass-movement of surficial materials akin to mud-flows, but, no linear mountain chains.

Not one of these three terrestrial sister-planets has crustal disturbances comparable to features generated on Earth. There are no great linear mountain belts like the North and South American Cordilleras, the Appalachians, the Mid-Atlantic Ridge, or the Mountainous linear chains of Asia; no arcuate features comparable to our island arcs; and no deep crustal trenches, unless *Valles Marinaris* on Mars, ascribed to erosion, is considered a trench. Moreover, the other planets have little or no evidence of any major forces of compression or tension on their surfaces in the past.
The dearth, or complete absence, of linear mountain chains on planets without the tidal

influences that a large satellite imposes on its primary is compelling; as such disturbance features have been developed repeatedly on Earth throughout its preserved history. This is particularly compelling when considering that the mass of our Moon, compared to Earth is the largest in the solar system. This fact cannot be excluded from the councils of those who would recast Earth history.

TABLE
Ratio of Planetary Mass to its Largest Moon

Planet	Satellite	Ratio of planet/satellite
Mercury	-	-
Venus	-	-
Earth	Moon	81.6
Mars	Phobos/Deimos	163 Bill.
Jupiter	Ganymede	12700
Saturn	Titan	4180
Uranus	Oberon	106
Neptune	Triton	1807

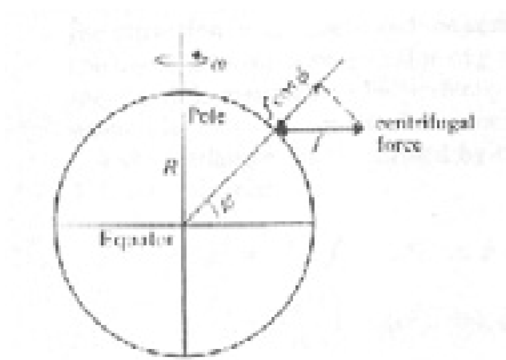
3.0 THE PHYSICS OF ROTATION

3.1 Centrifugal Force and Gravity

Since gravity plays a role in, and is the overseer in the flow and expenditure of dynamic energy in every physical process active in, on, and under, the Earth's crust; it is imperative that gravity and centrifugal force, the major factor altering gravity, be incorporated in our deliberations on Earth's geologic history.

Centrifugal force generated as a result of Earth's rotation (Length of Day), directly affects the value of gravity depending upon where it is measured. Other factors such as heterogeneity in the distribution and movement of mass, and oblateness, also affect local gravity, but, these have minor effects that do not influence the underlying principles discussed herein.

Suffice it to say here that the vector force of simple gravity is always directed toward the Earth's enter of mass, while the amplitude vector of centrifugal force (Fc), opposes, or reduces, gravity as a function of Earth's rate of rotation.



If the Earth were perfectly spherical in shape, the centrifugal force f, due to angular velocity Omega, would be at a latitude angle phi __:

(Fc) = omega^2 R Cos phi

Fig. 3.1.1 Centrifugal Force due to the rotation of the Earth

The component of Fc in the direction of the Earth's gravitational attraction is nearly equal to cos phi __ times f, or omega^2Rcos^2 phi___________. Its effect is to decrease the acceleration of gravity.

3.2 TIDAL FRICTION

The sun and the moon both exert tidal forces on the Earth retarding its rotation. Frequently this is called tidal "friction." A better term would be negative tidal torque. This element of force results from the gravitational attraction between the Earth, the Moon, and the Sun causing the Earth to constantly adjust its shape as it rotates. This adjustment, takes the form of rising and falling aqueous tides, plus tides beneath our feet within the solid body of the Earth. Approximately 70 to 80 percent of average tidal force is estimated attributable to the Moon, and 20 to 30 percent to the Sun (L.V. Morrison in Brosche and Sunderman 1978).

Because lunar tidal effects are dominant, the tide manifests itself as a bulge (like a standing wave) the crest of which always maintains a position ahead of a line drawn between the centers of the Earth and Moon in the direction of the Earth's rotation. This relationship, measured as an angle formed by line between Earth's center and the crest of the tidal bulge, and the Earth-Moon line of centers is called the *phase* angle. (Fig. 3.2.1)

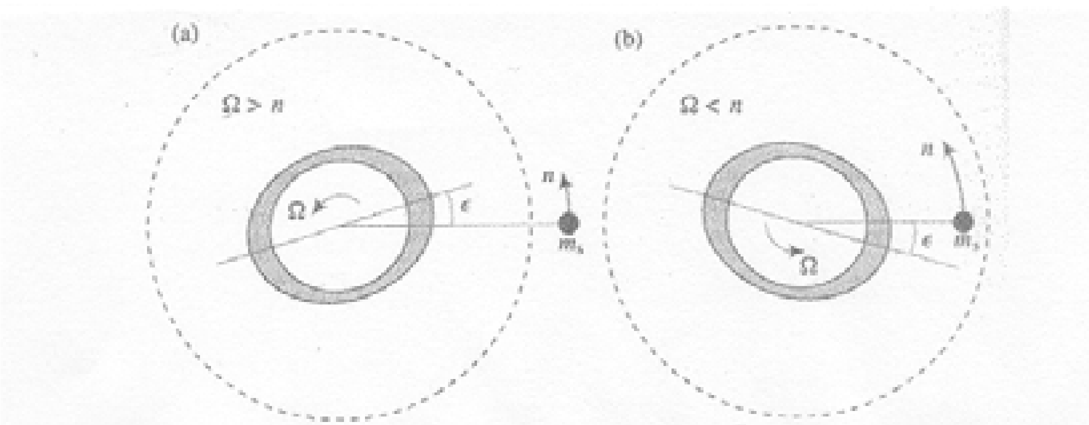


Fig. 3.2.1 These diagrams illustrate a satellite in circular orbit raising a semi-diurnal tide on a planet. (a) If Omega is > n the satellite is above synchronous height (dashed circle) and the tidal bulge is carried ahead of the satellite by *phase angle* E (b) If Omega is < n the satellite is below synchronous height and the tidal bulge lags behind the satellite.
(After Murray and McDermott, 1999)

The bulge crest never faces the Moon directly because the Earth is imperfectly elastic and time is required for ocean waters and Earth's bodily deformation to relax and re-adjust during rotation following the point of maximum Earth-Lunar gravitational attraction. The offset of this tidal bulge presently measures three degrees (*phase angle)* forward of the line of centers between Earth and the Moon. This results in a negative torque retarding Earth's rotation to slowly increase the length of day. The phase angle, as will be shown later, has probably changed through geologic time as a function of the Moon's distance from the Earth: the greater the lag or phase angle, the greater the torque and retardation.

This rate of slowing, presently believed to be about .0016 to .0018 second per century (our present Earth day is 23.93448 hrs), may sound insignificant and unworthy of consideration, but over Eras of geologic time, these bits of time add up to minutes, then hours. At a rotation reduction of .0017 sec/century, we lose 1.0 second from average daily rotation time in 58,823 years. Projected back to the beginning of Cambrian time 550 million years ago the day would have been 20.7 hrs or, 3.2 hrs less than today. Calculating back 1 billion years would give a day of 17.2 hrs.

There are, however, reasons to believe these figures may be too conservative. This will be discussed later.

Table 3.2A

LENGTH OF DAY vs. CHANGE IN NET EQUATORIAL GRAVITY

Daily Rotation Hours	Net Gravity Accel. in dynes	Percent Change From present
23.93	976.86	0.00
22.0	975.92	0.10
20.0	974.84	0.21
18.0	973.33	0.36
16.0	971.09	0.59
14.0	968.14	0.89
12.0	963.33	1.38
10.0	955.38	2.20
8.0	940.13	3.76
6.0	908.75	6.97
4.0	816.90	16.4

3.3 Rotation vs. Volume Reduction

In 1990 Denis and Varga examined the "Consequences of Earth's Variable Rotation." In their paper they reviewed the work of R. Stoneley, one of the earliest authors to address the relationship between Earth's rotation and volume

> "Stoneley (1924) was probably the first to consider shrinkage of the Earth's volume caused by tidal despinning in an attempt to explain mountain building. He found with the then admitted parameters describing the Earth's compressibility, that a slowing down of the rotation speed from a 12 hr. day to a 24 hr. day would reduce the Earth's radius by about 1.6 km . For the same change in rotation period our results lead to a decrease of the equatorial radius of about 16 km, and a concomitant increase of the polar radius of about 32 km."

(Note- CLH) my figures are 11 km equatorial Radius and 22 km polar radius respectively for decelerating from 12 to 24 hr days)

Denis and Varga continue—:

> "Using experimental values for the change of density of common rocks with pressure and an increase of Earth's gravity (i.e. Gravitational plus centrifugal acceleration) by about 3% over its history, we may infer a value of delta R / R comprises between 0.1% and 1.0%."

(CLH): These changes in gravity appear too small and do not adequately match my work which do not consider any resulting change in density (there would be)---- only the change in net gravity resulting from the change in centrifugal force and related changes in equatorial radius due to rotational flattening (oblateness).

Starting with a method of calculating planetary flattening developed by Murray and Dermott (2001) this author calculated Earth oblateness factors to compare these values to a separate series of oblateness values wherein polar radius was varied arbitrarily, while Earth volume was held constant to calculate oblateness (a-b)/a and the corresponding value for equatorial radius.

Using a series of the latter calculations developed within a range of planetary flattening values ranging from Saturn (.1022) through Earth (current= .0034) and on down to a sphere, it was possible to derive interpolated comparisons yielding estimated values for the Earth's equatorial radius at arbitrarily selected rates of rotation in the past, and hence to derive net effective gravity at daily rotation rates ranging from the present 23.93 hrs back to 4.0 hrs (arbitrary cut off)

Based on the foregoing, the change in net gravity from present equatorial acceleration force (976.86 dynes) , ranges from 0.096 % (.00096) less at a 22.0 hr day to a 16.37% reduction at a 4.0 hr. day (Table 3.2A). These value changes in net gravity may sound insignificant until the effects of even smaller value changes are calculated for crustal materials of different densities.
(Examples are given in Section 8.0)

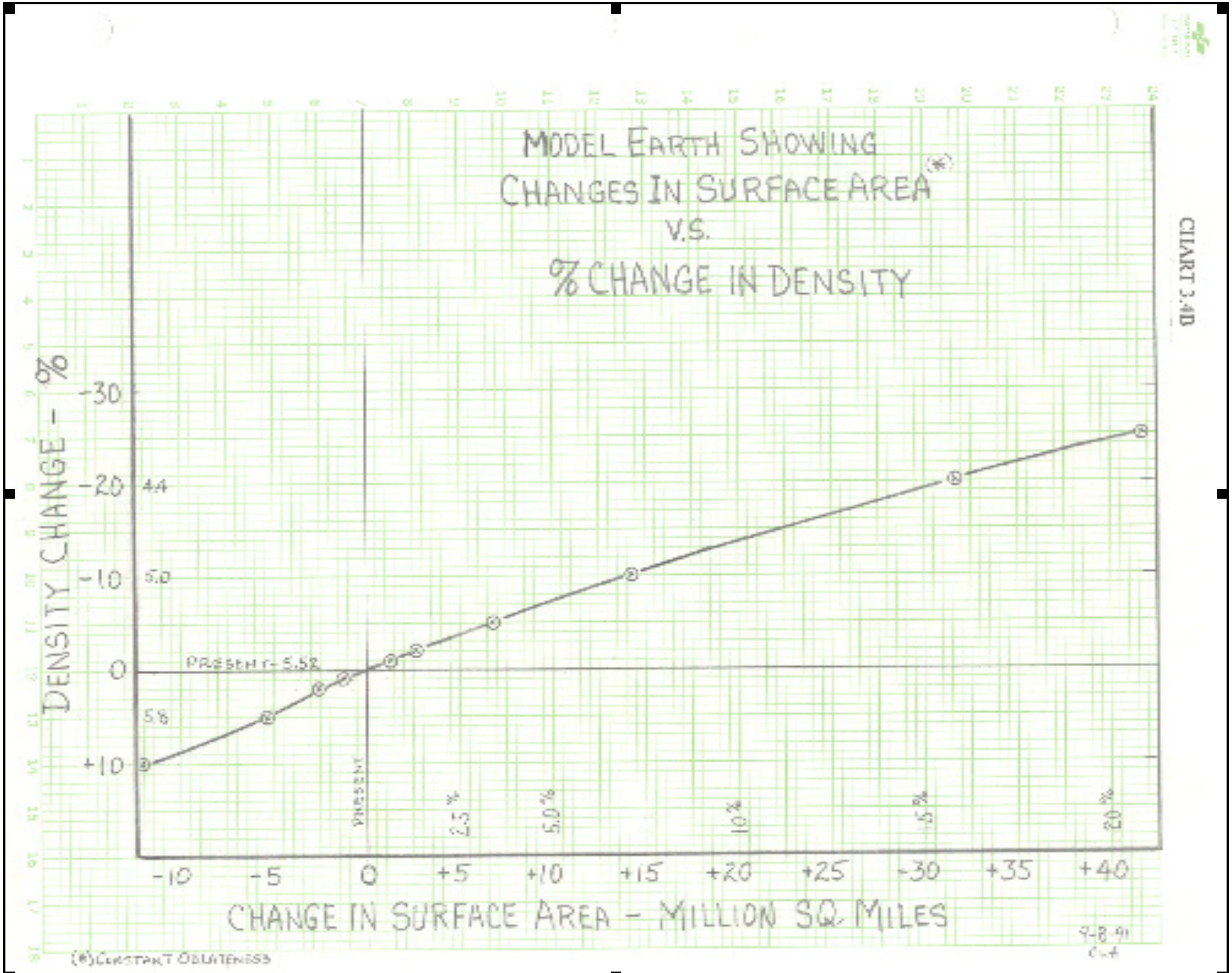
The following plotted chart depicts hypothetical changes in:

EARTH SURFACE AREA versus PERCENT CHANGE IN AVERAGE INTERNAL DENSITY

The figures for % of change in density are arbitrary. They were used to calculate the change in Earth volume, and from this a change in total surface area.

(present average Earth density is 5.52)

Density. increase from a paleo-value of:		Yields a reduction in surface area of:
4.97 to 5.52	(10.0%)	14.3 million sq. miles
5.24 to 5.52	(5.0%)	6.8 million sq. miles
5.46 to 5.52	(1.1%)	1.3 million sq. miles



MODEL EARTH SHOWING
CHANGES IN SURFACE AREA (*)
V.S.
% CHANGE IN DENSITY
CHART 3.4D
DENSITY CHANGE - %
-30
-20
4.4
-10
5.0
0
PRESENT - 5.52
5.8
+10
PRESENT
2.5%
5.0%
10%
15%
20%
-10
-5
0
+5
+10
+15
+20
+25
+30
+35
+40
CHANGE IN SURFACE AREA - MILLION SQ MILES
(*) CONSTANT OBLATENESS
9-8-91

4.0 BIOLOGICAL PALEO-CLOCKS

> *"All Earth sciences must contribute evidence towards unveiling the state of our planet in earlier times, and the truth of the matter can only be reached by combining all this evidence."*
>
> Alfred Wegener
> (Foreword to his book, *The Origin of Continents and Oceans)*

4.1 Introduction

There is a substantial literature on studies of both fossil and Recent Marine organisms relating to growth factors (lines) in shells as they are affected by tidal conditions. These include bi-valves, oysters, stromatolites, and corals. Tidal laminations in sediments have also been studied, but, with poor results.

The important conclusions are that all of the forgoing are affected in some manner by the variable conditions imposed during high and low tides. However, the results (excepting corals) when used as a measure of paleo-tides to project rotation and the number of earth days are inconsistent and generally not reliable.

Corals (specifically, rugose Horn Corals and others) are the known exceptions. Scrutton (1977), Pannella (1972), Wells (1970), Mazzullo (1971), and, Berry and Barker (1968) have published data on the number of Earth days per year obtained from paleontological data. Their figures are reasonably consistent with astronomical data and Earth-Moon geometry.

These fossil data are premised on the assumption that growth rings in the animals are reflective of environmental conditions created by the daily variations in light, darkness, and level of lunar tides. Experimental studies conducted on living marine bi-valves and corals generally support this view (Thompson, I. 1975)

Counts of growth rings have thus been taken to measure Earth's rotation relative to the moon, and, therefore, the number of Earth's solar paleo-days. Since the moon's orbital transits change with its distance from Earth (closer in the past), a question arises of whether growth rings keyed to tidal fluctuations is an accurate measure of Earth's past rotation. (See Lunar Orbits for discussion).

Earth's current rate of deceleration based on delays in lunar and solar eclipses indicates an average deceleration of about .0017 to .0018 second per century. Data from fossils, based on periods ranging back to 450 million years, yields a projected figure in the range of .0021 up to .00235 sec per century.

*   *   *

(See plot and spread sheet P-CLk3)

4.1 Growth Rings on Typical Rugose Horn Coral (Devonian)

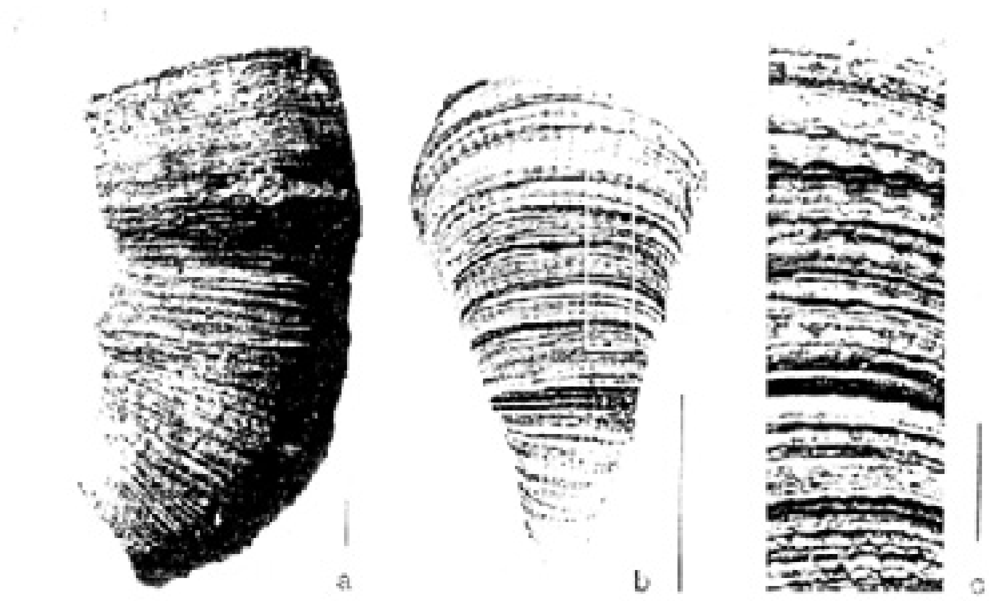


Figure 4.1.1

Growth increments on rugose corals. (a) Annulation and bands; scale 1 cm;
(b) bands; scale 1 cm; (c) enlargement of part of (b) to show growth ridges in four complete bands; scale 2 mm. Both specimens *Heliophyllum halli: a)* Middle Dev. Hamilton Group; New York, USA : (b & c) Middle Devonian , Traverse Group, Michigan. USA (From Scrutton, C.T. 1977)

P-CLK3A
VARIOUS AUTHORS

PALEONTOLOGIC CLOCKS
Various Authors

TABULATED
1-17-2000

Three plotted curves   Approx. rate of rotational change/century over last 450 million Yrs =.00235 secs.

AUTHOR & YEAR OF PUBLIC.	X SCALE BASE	EPOCH	?? AGE MMYR Est. Approx.	AVERAGE COUNT PER GRO ANNULAT	N2 DAYS PER SYNODIC MONTH PRES.= 29.53	N3 ASSUMED SYNODIC MO/YEAR ?????	N1 PALEO DAYS PER YEAR	SECNDS IN SIDRL YR 365.256d X 23.934h X3600 s/h	HOURS IN PALEO DAY	REDUCTION FROM CURRENT DAY 23.93448h	TOTAL SECONDS CHANGE FROM PRESENT	RATE OF CHANGE PER CENTURY SECS.
A	B	C	D	E	F	G	H	I	J	K	L	M
Wells- 1970	0	RECENT	0	360					23.94			0.00170
Pannella-1972		RECENT	1	359					23.94			
Pannella-1972		U.CRET.	70	375			375	31471982	23.31	0.622	2238.89	
Melchoir,P.		CRET.**	72				370	31471982	23.63	0.307	1104.74	0.00153
	100	CRET.	100				370	31471982	23.63	0.307	1104.74	0.00110
		CRET.	100				375	31471982	23.31	0.622	2238.89	0.00224
Pannella-1972	220	M.TRIASSIC	220	372			372	31471982	23.50	0.434	1562.06	0.00071
		TRIASSIC	230				372	31471982	23.50	0.434	1562.06	0.00068
		PERMIAN**	270				384	31471982	22.77	1.168	4205.92	0.00156
		PENNSYLV	285				385	31471982	22.71	1.227	4418.81	0.00155
Pannella-1972		U.CARB.	290	383			383	31471982	22.83	1.109	3991.93	0.00138
Melchoir,P.		CARB.	298				387	31471982	22.59	1.345	4841.27	0.00162
Wells- 1970	300	U.CARB.	300	385			385	31471982	22.71	1.227	4418.81	0.00147
Wells- 1970		L.CARB.	320	398		??	398	31471982	21.97	1.969	7088.94	0.00222
Pannella-1972		L.CARB.	340	398			398	31471982	21.97	1.969	7088.94	0.00208
	350	DEVON.	350				398	31471982	21.97	1.969	7088.94	0.00203
Pannella-1972		M.DEVON.	360	406			406	31471982	21.53	2.402	8647.10	0.00240
Scrutton-1970		M.DEVON.	370	401			401	31471982	21.80	2.133	7680.53	0.00208
Wells- 1970		M.DEVON.	370	398			398	31471982	21.97	1.969	7088.94	0.00192
Mazzullo-1971		M.DEVON.	370	405			405	31471982	21.59	2.349	8455.70	0.00229
Melchoir,P.		DEVONIAN**	380				398	31471982	21.97	1.969	7088.94	0.00187
Mazzullo-1971	405	Lr. DEVON.	405	410			410	31471982	21.32	2.612	9403.38	0.00232
Wells- 1970		M.SILURIAN	420	400			400	31471982	21.86	2.079	7484.32	0.00178
Mazzullo-1971		SILURIAN	430	419			419	31471982	20.86	3.070	11052.22	0.00257
Melchoir,P. (**)		M.SILURIAN	440	407			407	31471982	21.48	2.455	8837.56	0.00201
Mazzullo-1971		Lr.SILURIAN	440	421			421	31471982	20.77	3.169	11409.05	0.00259
Wells- 1970	445	U.ORDOVIC.	440	412			412	31471982	21.22	2.716	9776.01	0.00222
McGugan-1967	550	M.CAMBRIAN	550	424			424	31471982	20.62	3.316	11937.99	0.00217

Avg. Value over 450 mm yrs. =   21.00   2.934 10561.34   0.00235 Sec avg. rate of chng/ century

Note: (**) data from P.Melchoir,Tides Of The Earth

PDYRATES

1-27-2000

ONE CHART

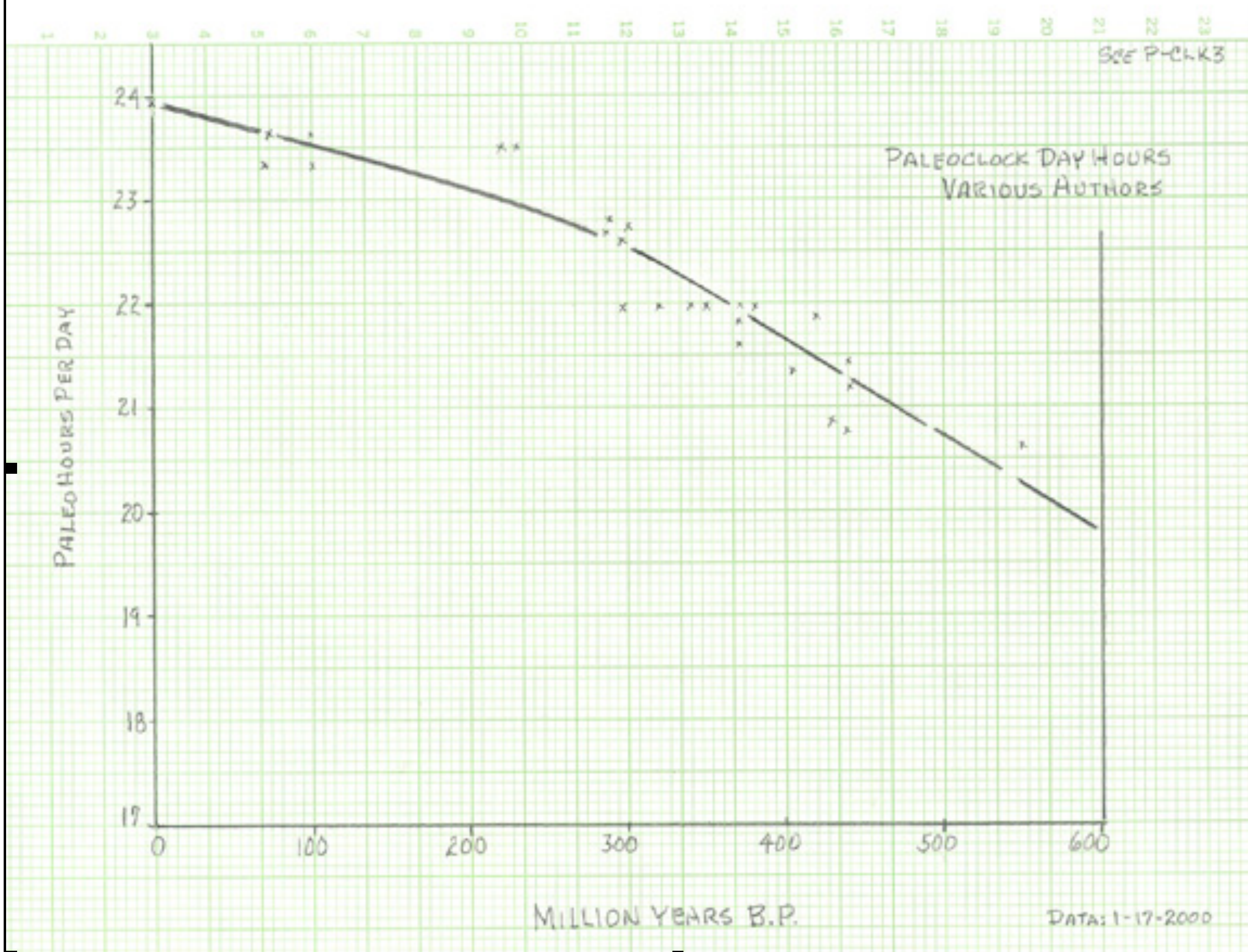
EXTRAPOLATED Paleoday Rate curves

Paleodays at different rates
of change per century

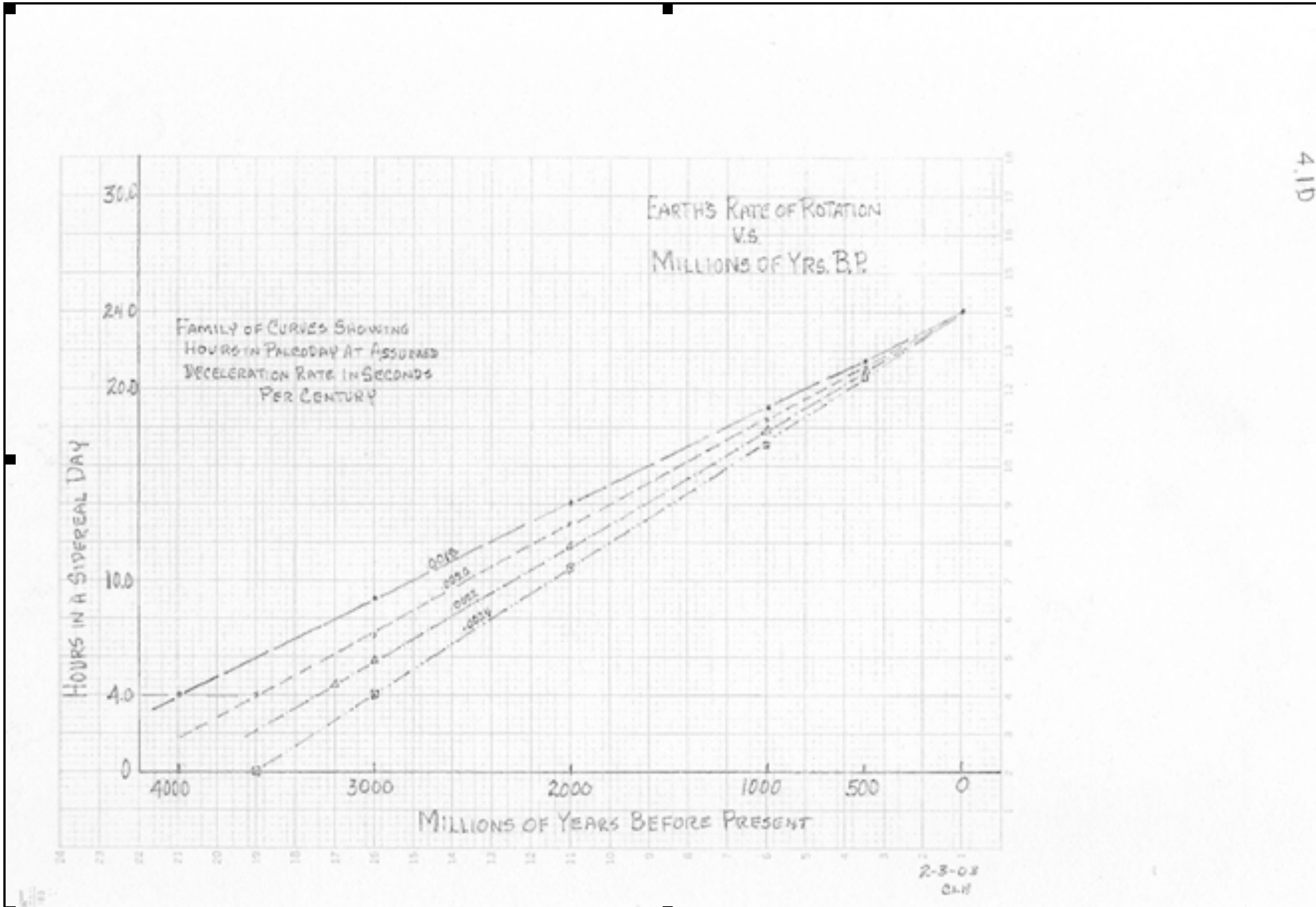
Note: On the face of it, these curves surely support the concept that the earth's length of day was significantly shorter in the past than it is to day---even if one uses only the lower rates of slowing that are supported by paleo and historic observations of astronomical data.

AGE TIME B.P. MILLION YEARS		NO. OF CENTURIES B/100	RATE OF GAIN PER CENTURY	CUM. TOTAL SECONDS GAINED C*D	GAIN IN HOURS SINCE B.P. E/SECS/HR	LENGTH DAY B.P. @ RATE .0016s/cy 23.934(-)F	LENGTH DAY B.P. @ RATE .0018s/cy 23.934(-)F	LENGTH DAY B.P. @ RATE .0020s/cy 23.934(-)F	LENGTH DAY B.P. @ RATE .0022s/cy 23.934(-)F	LENGTH DAY B.P. @ RATE .0024s/cy 23.934(-)F	LENGTH DAY B.P. @ RATE .0026s/cy 23.934(-)F	LENGTH DAY B.P. @ RATE .0028s/cy 23.934(-)F	LENGTH DAY B.P. @ RATE .0030s/cy 23.934(-)F
A	B	C	D	E	F	G	H	I	J	K	L	M	N
0						23.9345	23.9345	23.9345	23.9345	23.9345	23.9345		23.9345
200	2E+08	2000000	0.0016	3200	0.8888714	23.0	22.9	22.8	22.7	22.6	22.5	22.4	22.3
400	4E+08	4000000	0.0016	6400	1.7777429	22.2	21.9	21.7	21.5	21.3	21.0	20.8	20.6
600	6E+08	6000000	0.0016	9600	2.6666143	21.3	20.9	20.6	20.3	19.9	19.6	19.3	18.9
800	8E+08	8000000	0.0016	12800	3.5554858	20.4	19.9	19.5	19.0	18.6	18.2	17.7	17.3
1000	1E+09	10000000	0.0016	16000	4.4443572	19.5	18.9	18.4	17.8	17.3	16.7	16.2	15.6
1200	1E+09	12000000	0.0016	19200	5.3332287	18.6	17.9	17.3	16.6	15.9	15.3	14.6	13.9
1400	1E+09	14000000	0.0016	22400	6.2221001	17.7	16.9	16.2	15.4	14.6	13.8	13.0	12.3
1600	2E+09	16000000	0.0016	25600	7.1109716	16.8	15.9	15.0	14.2	13.3	12.4	11.5	10.6
1800	2E+09	18000000	0.0016	28800	7.9998431	15.9	14.9	13.9	12.9	11.9	10.9	9.9	8.9
2000	2E+09	20000000	0.0016	32000	8.8887145	15.0	13.9	12.8	11.7	10.6	9.5	8.4	7.3
2200	2E+09	22000000	0.0016	35200	9.7775860	14.2	12.9	11.7	10.5	9.3	8.0	6.8	5.6
2400	2E+09	24000000	0.0016	38400	10.666457	13.3	11.9	10.6	9.3	7.9	6.6	5.3	3.9
2600	3E+09	26000000	0.0016	41600	11.555328	12.4	10.9	9.5	8.0	6.6	5.2	3.7	2.3
2800	3E+09	28000000	0.0016	44800	12.444200	11.5	9.9	8.4	6.8	5.3	3.7	2.2	0.6
3000	3E+09	30000000	0.0016	48000	13.333071	10.6	8.9	7.3	5.6	3.9	2.3	0.6	-1.1
3200	3E+09	32000000	0.0016	51200	14.221943	9.7	7.9	6.2	4.4	2.6	0.8	-1.0	-2.7
3400	3E+09	34000000	0.0016	54400	15.110814	8.8	6.9	5.0	3.2	1.3	-0.6	-2.5	-4.4
3600	4E+09	36000000	0.0016	57600	15.999686	7.9	5.9	3.9	1.9	-0.1	-2.1	-4.1	-6.1

TABLE 4.1B Extrapolated Paleoday Rates



4.1C Chart Paleoclock Days



EARTH'S RATE OF ROTATION
V.S.
MILLIONS OF YRS. B.P.
FAMILY OF CURVES SHOWING
HOURS IN PALEODAY AT ASSUMED
DECELERATION RATE IN SECONDS
PER CENTURY
HOURS IN A SIDEREAL DAY
30.0
24.0
20.0
10.0
4.0
0
4000
3000
2000
1000
500
0
MILLIONS OF YEARS BEFORE PRESENT
2-3-08
C.L.H

4.1D

5.0 THE LUNAR ORBIT

5.1 EARTH ROTATION RELATIVE TO LUNAR ORBIT

Introduction:
In section 4.1 on Paleoclocks it was indicated that the number of tides is determined by Earth's rotation relative to the orbiting Moon. If the number of Lunar orbits was greater when the Moon was close, Earth's rotation could also have been more rapid, nullifying fossil growth rings and a count of tidal events as an accurate measure of the length of day.

It was thus necessary to project backward in time to model different rates of Lunar recession and calculate the Moon's orbital distance and the length of a synodal month (time for one full orbit), then compare these values with projected Earth days for the same time periods back to the Archaeozoic, then judge Earth's rotation based on realistic average rates of Earth deceleration.

A rough analysis using Lotus spread sheets was used to calculate and compare the result of varying constant rates of lunar recession from Earth over various periods of time back to 4 billion years.

Different rates of Lunar recession (3.82, 4.00, 5.50, and 7.77 Cm per year) were used as variables to calculate B.P. distances. Also, the average rate of slowing in Earth deceleration ranging from .0018 sec/ century up to.0030 sec/cy were used as variables in each of these data sets to observe the effects of these factors on the relationship between the Earth's daily rotation and the Moon's period of orbit in seconds depending upon it's distance from the Earth as calculated by Kepler's Third Law of planetary motion. (Fig. 5.1.1)

The objective was to see if the Earth may have rotated at a substantially greater rate when the moon was closer in B.P. time. This approach is mathematically very crude yet it did suggest that the range of possible changes in the rate of deceleration did not vary substantially from an overall average rate of less than .0018 sec/cy to much beyond .0022 or .0023 sec/cy even when modeling distances no closer than about 100,000 miles looking back to 4 billion years.

The point of this modeling was to investigate whether fossil growth rings, as a numerical indication of earth tides, were thus a direct measure of Earth's rotation independent of the moon's orbital position and angular velocity, or whether Earth's spatial rotation could be faster than suggested by tidally controlled fossil growth rings.

Conclusion:

While the Earth may have had solar days of perhaps 21 hours in Cambrian time (500 million yrs. B.P.), and 12 hours, or a bit less at 2.0 billion yrs. B.P., the Earth's daily rotation probably did not range too far from these values. At assumed average deceleration approaching .0030 sec/cy and above, curve sets beyond 2 billion yrs. develop unrealistic values. Non-the-less, beyond about 2 billion yrs to 4 billion yrs Before Present (B.P.). Earth rotation could have been as rapid as two or three hours if it is assumed that the Moon , at some point in time, was situated at a distance of less than 50,000 to 100,000 miles, but outside of Roche's limit at 2.8 times the Earth's radius. This would then require a much higher rate of deceleration in the early years when the moon was in close orbit. This may be speculative. It is, however, a view concluded also by physicist Alan H.Cook (1988): pg. 203.

> "......in discussions of the evolution of the system of the Earth and the Moon over thousands of millions of years, tidal dissipation and elastic yielding are not just not negligible, they control the course and history of the system."
>
> "The distance of the Moon from the Earth has changed by large factors as a consequence of tidal dissipation, which was much greater when the two were much closer than now."

Presently, the equatorial radius of Earth is 3962 miles (6378.14 Km). At higher rates of rotation in B.P. time, the Earth's oblateness and hence its equatorial radius would have been greater, as would the distance to Roche's Limit. At Roche's Limit, the moon, if it existed then and had been within that radius, would have been torn apart. One may therefore conclude that the Moon
(as we know it) was unlikely to have been much closer than 100,000 miles distant. (62,000 km)

The foregoing also lends additional validity to data on the length of Earth days based on fossil organisms. Extensive investigation by a number of authors supports a correlation of growth rings in fossil corals with tide cycles, but, data based on fossil bivalves, stromatolites, and tidal annulation in sediments is inconsistent and tenuous.

If tides were (are) the controlling factor in fossil growth rings, then the rings, at least back to early Cambrian, would represent a minimum rotation rate (relative to the Moon) when actual spatial rotation relative to the sun may have been greater.

As is illustrated mathematically and discussed in section 5.3 titled, "EARTH DAYS vs. TIDES" (and three accompanying spread sheets:LUN457v2), it is clear that if we assume coral growth rings are controlled by and are a measure of tides, then the number of counted annulations must be corrected by adding the number of annual lunar orbits to obtain annual Earth rotations. Presently, this number is 13.33.

This makes clear also, that Earth rotation in Devonian time, around 22 hours based on fossil corals, is a function of two variables, namely; the Moon's orbital distance and the rate of Earth's deceleration. These values may be more accurately calculable, but, are not known (to the author) presently. We do, however, know that the paleo Earth-day may have been somewhat shorter than it is currently projected, and that the farther we look backward in time, the disparity between projected rates of deceleration and possible actual rates will grow.

For purposes of understanding Earth history and the tectonic forces operational from the beginning of the Paleozoic to the Present, we can probably set aside, at least for the present, speculations about Earth-Moon orbital relationships before the Proterozoic. The data in hand can easily support a hypothesis that rotational deceleration and the effects of increasing gravity are the dominant mechanisms of Earth's crustal unrest.

* * *

5.2 Kepler's Third Law of Motion

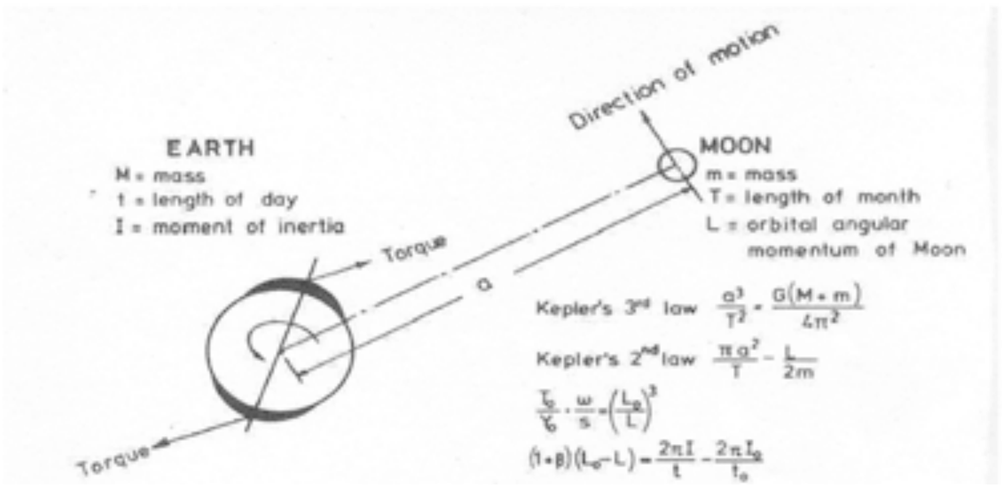


Figure 5.2.1 Basis for computing tidal recession of the Moon from the Earth

5.3 EARTH DAYS vs TIDES

Present Given Values

Lunar orbital velocity = 2.66198×10^{-6} Radians/ sec^{-1}
Earth rotational velocity = 7.29213×10^{-5} Radians/sec

Dividing: $\frac{\text{Omega (E)}}{\text{Omega(L)}} = \frac{7.29213 \times 10^{-5}}{0.2661698 \times 10^{-5}} = 27.3966$ Days in a Lunar Month

And 27.3966 x 13.3322 (lunar Mo/yr.) = 365.256 Earth days /sidereal yr.

Some Calculations:

During one sidereal Earth year there will be the following number of annual tides:

1) with a "fixed " moon: = 365.256 tides

2) with an orbiting moon: = causes the loss of one Earth tide per Lunar orbit.
Or a loss of 13.332 tides per Earth year.

3) therefore, the No. of annual Earth tides = 365.265 (-) 13.332 = 351.92 tides / year.

The foregoing demonstrates that a count of "annual" growth rings observed on marine paleo-organisms keyed to tides as indicating the number of sidereal Earth-days will always understate the number of actual sidereal days in an earth-year. This is true even if perfect conditions enabled the recordation of each diurnal tidal cycle throughout a year. The statement will be an inverse function of the number of days in a lunar orbit, i.e., in the geologic past when the moon was closer to the earth and orbited more rapidly, the number of growth rings on corals and bi-valves (thought to be tidally controlled) will always be less than the number of solar days. Therefore, more accurate estimates of Earth-days (rotation) will be obtained by adding to the growth count, the number of Lunar months in a projected paleo-year. As will be illustrated shortly, this becomes extremely important the farther back in time we look.

5.3a Calculations — TEST EXERCISE (1)

Assumptions:

Synodic (Lunar) mo/yr. = 19.0 mo./yr. (Present is 13.33 mo/yr)
Solar days per year = 575 paleo-days/ yr.

1) Radians traversed in orbit per Lunar yr. = 19.0 x 6.28318 = 119.380 Radians
and the seconds in one Earth yr.= 86164.1 sec/dy x 365.256 = 3.14719×10^{7} Seconds

2) Radians /sec @ 19.0 lunar mo/ yr. = $\frac{119.380 \text{ R}}{3.14719 \times 10^{7} \text{ sec}} = 3.79322 \times 10^{-6}$ Rads/sec (ω_L)

3) Earth Omega @ 575 dy/yr = 575 x 6.28318 Rad/360 deg. = 3612.828 Radians / Earth yr.
And Rad/ sec = $\frac{3612.83 \text{ Rad/yr}}{3.14719 \times 10^{7} \text{ sec/yr}} = 1147.954 \times 10^{-7} = 114.7954 \times 10^{-6}$ Rad/sec (ω_e)

5.3b TEST EXERCISE (II)

Assumptions: (Taken from Astronomy Text w/ ref to G.H. Darwin)

Moon Distance from Earth = 10,000 Miles (this is inside Roche's Limit @ 11777 Mi.)
The length of the lunar month was "something less than a quarter of the present month;

This would be roughly 27.4 dy x 0.25 = 6.85 dy/ Lunar mo.

And, $\frac{365.256}{6.85}$ = approx 53 Lunar months per yr

1) Lunar Radians/Earth yr = 53 x 6.2832 = 333.0 Radians/ yr

2) Lunar orbital rate = $\frac{333.0 \text{ Rad}}{3.14719 \times 10^{7} \text{ sec in Earth yr.}} = 105.80 \times 10^{-7}$ Radians / sec

Darwin continued: "the day was a still smaller fraction of 24 hours"
Lets use 22% of 24 hrs. = 5.25 hrs

3) Then, Lunar orbital Omega in Rads/ sec would be:
5.25 hrs x 60 x60 = 18900 seconds to rotate 360 degr. Or, 6.2832 Radians
and, $\frac{6.2832}{1.8900 \times 10^{4}} = 3.3244 \times 10^{-4}$ Radians / sec

4) Number of seconds in 365.256 dys = 86164.1 x 365,256 = 3.14719×10^{7} seconds

5 Therefore, the number of rotations (solar days) in one Earth year of 365.256 days
is: $\frac{3.14719 \times 10^{7}}{1.8900 \times 10^{4}} = 1.6652 \times 10^{3}$ = 1665 days per Earth year.

But, we must correct this figure to determine the number of Lunar induced Earth tides each sidereal year. There will be a loss of 1.0 tide each lunar monthly cycle. And at an Earth rotation of 5.25 hrs and 1665 days per year, there would be: 1665 (-) 53 = 1612 tides per year.

This, of course is a purely hypothetical example as it would mean there would be two high tides each Earth.rotation(day). These would be only 2 ½ hours apart with a low tide in between. Impossible. But, the calculations in this exercise do provide insight into the havoc that would be imposed on a developing Pre-Archean Earth's crust by an Earth-day of 5.5 to 6.0 hours with a Moon orbiting close to Roche's Limit at about 11,800 Miles distance from the Earth once about

Note also, that the "lag" in the tidal bulge would be markedly increased under these early conditions. The present tidal *phase angle* is about 3 degrees. At higher rates of rotation and much stronger tidal influences, the tidal bulge would be much larger (higher) and the phase angle much greater. This would have several direct effects:

1) Tidal torque (friction) would be significantly larger; decelerating Earth rotation at a higher rate.

2) A greater force of tidal torque imposed upon developing continental plates would tend to drive them westward and thus provide and understandable mechanism for continental drift.

3) The Earth would be more oblate, accelerating Earth precession and polar axis orientation to the ecliptic plane.

4) Longitudinal *offset* of lithic plates north and south of the equator would cause N-S vectored tidal torque forces that could move continental plates in southerly and northerly directions.

5) A shift of crustal plate mass could cause precession that could shift moderately the geographic poles.

* * * *

5.4 REVERSING LUNAR RECESSION
(Spreadsheets LUNR @ 4.0, 5.5, & 7.7 cm/yr)

This series of three spreadsheets was designed to calculate the average radius of the lunar orbit looking backward from Present to 4 Billion years BP using increments of 100 million years at arbitrary lunar recession rates of 4.0, 5.5 and 7.77 cm per year and other related factors in conformance with Kepler's third Law.

Additionally, the Earth's rate of deceleration attributable to Lunar tidal torque was examined at various rates. Since the present average rate of deceleration in the Earth day accepted by most researchers ranges between .0016-.0018 sec/per century, and figures obtained for paleo-days ranging back through the lower Paleozoic based on marine fossil organisms gives retardation values between about .0020 and .0025 second / century, I used .0021 as a reasonable approximation for tidal slowing in the time intervals of greatest concern, considering also, that when the Moon was closer to the Earth, tidal forces would have been greater and the retardation rate more severe.

In the course of plotting curves of the length of Earth days in relation to the length of Lunar orbits (i.e. The number of Earth paleo-days per Lunar Month) using varying rates of rotational deceleration at three Lunar recession figures of 4.0, 5.50 and 7.77 cm per year it was noted that when Earth deceleration was held @.0021 sec/cy for all three lunar recession rates, the plots of days per Lunar month @ the 7.77 recession rate actually declined from the origin of the plot back to about 1.6 billion years. When the 7.77 recession plot was used with an assumed rate of .0030 sec/cy and even up to .0035 sec/cy, the curve climbed to essentially parallel the 4.0 and 5.50 plots using deceleration rates of .0021 sec/cy back to BP time of 1.0 billion years and earlier.

What this strongly suggests is that because both the Earth's rate of rotation (angular velocity) and the Moon's orbital rate (angular velocity) were changing back to some indeterminate point in time, the number of Earth tides induced by lunar gravity in the course of one Earth-year (essentially constant thru time), the rate of the Earth's rotation is not necessarily a measure of the number of tides generated by its rotation relative to the Moon.

Stated differently, we are dealing with two time variables and two variables in angular velocity -----the Earth's rotation and the Moon's orbital rate as they relate to another time factor that is fixed, the Earth year.

From this, and the estimated values used in the model examined we can say that using phenomena related to the rise and fall of tides, (i.e. Marine fossil growth rings, stromatolites, and sedimentary laminae) are a laudable first approach to seeking the length of Earth days in it's earlier history, it is virtually certain that these methods can not, no matter how well refined, yield a reliable answer to Earth" absolute spatial rotation.

It should be accepted that the Earth' rate of rotation was probably greater, and the day shorter, than what has recently been generally projected. The implications relative to geologic history are substantial.

5.4a

TABLE 1
Lunar-earth Relationships at B.P. Time
With Lunar Recess @ 4.0cm/yr and
Earth deceleration @ .0021 sec/ Century

B.P. TIME in My Yrs.	Lunar Dist. In miles	Paleo-day In Hours	Lunar Orbits Per Earth Yr.	Lunar Ang. Vel. In Rad/ sec E-06	Earth Ang. Vel. In Rad/sec
0	238848	24.0	13.38	2.66	72.7x E-06
100	26363	23.42	13.6	2.71	74.5x E-06
200	233877	22.83	13.81	2.75	76.4x E-06
300	231392	22.25	14.04	2.79	78.4x E-06
400	228906	21.67	14.27	2.84	80.5x E-06
500	226421	21.08	14.5	2.88	82.8x E-06
1000	213994	18.17	15.78	3.14	96.0x E-06
1500	201566	15.25	17.27	3.44	114.x E-06
2000	189139	12.33	18.99	3.78	141x E-06
2500	1776711	9.42	21.03	4.19	185x E-06
3000	164286	6.50	23.46	4.67	268x E-06

TABLE 2
Lunar-earth Relationships at B.P. Time
With Lunar Recession @ 5.5 cm/yr and
Earth deceleration @ .0021 sec/ Century

B.P. TIME in My Yrs.	Lunar Dist. In miles	Paleo-day In Hours	Lunar Orbits Per Earth Yr.	Lunar Ang. Vel. In Rad/ sec E-06	Earth Ang. Vel. In Rad/sec
0	238848	24.0	13.38	2.66	72.7x E-06
100	235431	23.42	13.68	2.72	74.5x E-06
200	232013	22.83	13.98	2.78	76.4x E-06
300	228596	22.25	14.30	2.84	78.4x E-06
400	225178	21.67	14.62	2.91	80.5x E-06
500	221761	21.08	14.96	2.98	82.7x E-06
1000	204673	18.17	16.87	3.36	96.7x E-06
1500	187585	15.25	19.23	3.83	114.x E-06
2000	170498	12.33	22.19	4.42	141x E-06
2500	153410	9.42	26.00	5.18	185x E-06
3000	136322	6.50	31.04	6.18	268x E-06
3500	119235	3.58	37.95	7.55	487x E-06

6.0 TIDAL TORQUE DECELERATION FACTORS

6.1 Tidal Friction vs. Tidal Torque

A large amount of effort, time, and text has been expended in attempting to divide “tidal friction” into portions which may be assigned, respectively, to aqueous friction imposed by tidal motion in shallow seas, deformation of the Earth in body tides, and on the conversion of kinetic energy into thermal energy, both within ocean waters and in possible internal magma bodies..

These efforts at detail may well be useful and valid to seek answers for some types of Investigations; the concept of “friction” vs. torque may, however, hinder analysis of lunar- solar tides in understanding their effects on tectonics and their inter-relationships over periods of geologic time.

In regard to tectonic factors, the term “tidal torque” would seem to be the more useful term. This is not to argue that friction induced by tides plays no role in deceleration. It surely does. But, clearly, calculating the loss of energy from rotational momentum due to friction is largely a task of “guesstimation.”

A value for energy lost in despinning through tidal torque imposed on Earth by the Moon is easier to calculate and more accurate. We know from laser reflectors placed on the moon by astronauts that the Moon is receding from the Earth at an average of about 3.6 to 3.8 centimeters per year. This results from the gravitational attraction between the Earth’s tidal bulge which remains like a “standing wave” in a position three degrees (the phase angle) forward of the line of centers between the Earth and the Moon. (Fig. 6 .1.1)

Thus, the mutual gravitational attraction between the mass in the tidal bulge and the lunar mass creates a torque on both bodies: The Earth is retarded in rotation; the Moon is accelerated in its orbit; which by Kepler’s Third Law of Motion must increase in radius. i.e. its distance from Earth.

There now remains only the task of computing the energy required to accomplish the Moon’s acceleration. This will be the precise amount of energy subtracted from Earth’s rotation and transferred to the Moon by mutual gravity. It will not, of course, include losses due to friction, or a small but indeterminate transfer of momentum to Earth’s solar orbit. (Brosche and Sunderman 1990).

For the consideration at hand, that of qualitatively judging the effects of tidal torque on deceleration, and thus, on net g and tectonics, we need only be able to demonstrate that a significant portion of Earth’s deceleration arises from negative torque both presently and over geological time. The additional loss of rotation through friction converted into thermal energy serves mostly to enhance conclusions reached about tidal torque on gravity. This is “frosting on the cake.”
The steady westerly force vector imposed on the crust by tidal torque may also be a factor to consider in the tectonics of “drift.”

6.2 Tidal Torque Factors

How much energy is required to accelerate the moon in its orbit so that it will recede from the Earth by a distance of 3.8 cm annually? This latter figure was obtained by laser measurements from reflectors placed on the moon by astronauts.

The answer to this question will be the Lunar portion of tidal torque imposed upon the Earth slowing its rate of rotation. An additional element of tidal retardation is the Sun's contribution to Earth tides, estimated at about 12 to22 % (Munk & McDonald, 1960), (Lambeck, 1980). This energy of retardation will also be a measure of the total force exerted on the Earth's tidal bulge by the interaction of Earth-Lunar gravity, and may be a qualitative and partially quantitative measure of a westerly directed force available to produce continental drift.

Other authors have viewed "tidal friction" as being the amount of drag or friction resulting from tidal flow in the sea and the movement of currents relative to the bottom of coastal shelves and estuaries. There is also an element of internal friction resulting from the rise and relaxation of the constantly moving tidal bulge. This deformation creates frictional energy dissipated as heat.

The tidal bulge is a constant deformation of the Earth's elliptical spheroid created by mutual Earth-Lunar-Solar gravitation. The bulge maintains a fixed relationship toward the moon and hence travels around the Earth as it rotates. The bulge results from the levitation not only of tidal waters, but, also from deformation of the globe and temporary elevation of the lithic crust. Because the Earth is imperfectly elastic, there is a time delay before the bulge reaches its maximum and begins to recede relative to a fixed point on the surface. This delay causes the bulge to maintain a position that is presently 3 degrees in the direction of rotation past a line drawn between Earth-Moon centers.

Several authors have speculated that in past geologic periods, extensive portions of the seas may have been quite shallow, a condition imparting more surface drag than would deep seas. The degree to which this flow of tidal waters might impose a greater or lesser "friction" to retard Earth rotation is a speculation of less consequence than the torque effected by the tidal bulge.

If we project present Lunar retreat backward in time, we see that the moon was closer while the Earth rotated more rapidly. In the past, the bulge would have been more pronounced and the delay, termed the "phase angle" would have been larger. Consequently, tidal torque produced by the bulge would have been greater. Most of this retardational torque would be attributable to gravitation between the crest of the bulge and the body of the moon. A large phase Angle would exacerbate this torque. (Fig. 6.2.1a)

In judging the relative proportion of torque generated by the aqueous tides, consider a hypothetical case where the Earth is almost perfectly elastic and delay angle is zero. (Fig. 6.2.1 b)
Since the bulge is now closely symmetric with the line of centers, there would be no torque attributable to lithic gravitation.
For the same reason, torque related to aqueous tides should be minor as, theoretically, any tidal

drag due to the flow of advancing and retreating waters on either side of the bulge will on average be nearly equalized.

(a)

(b)

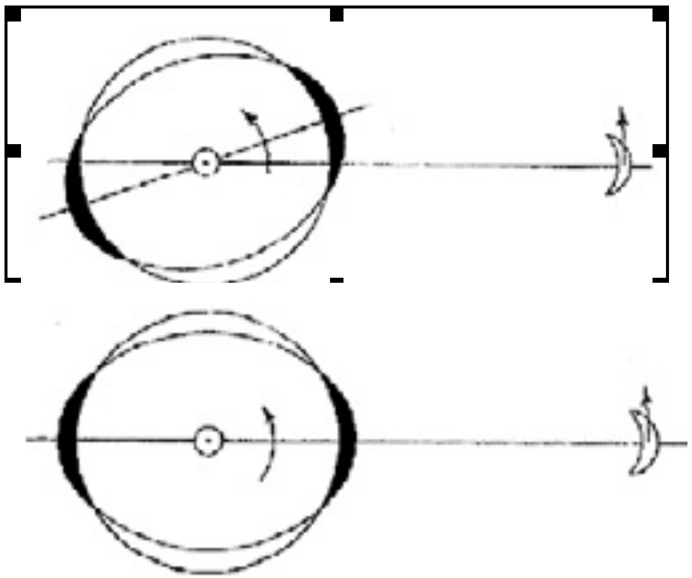


Figure 6.2.1

The upper diagram (a) shows the case for torque (friction) with a *phase angle* delay in the time of high tide. The resulting distortion of the tidal bulge leads to a deceleration of the Earth's rate of rotation, and an acceleration in the Moon's orbital motion.
(b) Lwr. Diagram shows tidal bulge if *phase angle* is zero and there is no torque.

To summarize, for the actual case where we *do* have a 3 degree delay angle in the tidal bulge, acceleration of the moon in its orbit is due entirely to gravitational attraction between the moon and the tidal bulge. It is speculated that the torque generated thereby can be allocated dominantly to the lithic part of the bulge and much less to the aqueous portion. In a relative sense, while surface tidal friction and internal friction are present, negative lunar torque appears as the dominant factor in retardation.

If the foregoing speculations are correct, the attribution of lunar torque as an agent slowing he Earth's rotation for a large, but, indeterminate part of Earth history, can be qualitatively calculated to compare with assumed rates of recession of the lunar orbit. The answer to this calculation may also provide an insight into the search for a potential driving force long sought for the continental drift hypothesis

* * *

6.3 Tidal Torque & Angular Momentum

Physicists (and others) concerned with the relationship between earth tides, rotation, and their effects on the Moon's orbit inevitably confront the problem of the conservation of Earth's rotational angular momentum. Any suggestion that Earth's Angular Momentum loss is not fully conserved as angular momentum elsewhere in the system is usually regarded as anathema.

Calculations always involve the transfer of angular momentum from Earth's rotational deceleration to an assumed primary role in the acceleration of Moon's Angular velocity and hence an increase in Moon's orbital angular momentum (*vmr*). Such efforts always fall short of a complete answer.

We may ask, then; is it always true that all angular momentum lost by the Earth in decelerating must transfer to the moon or to Earth's solar orbit so that there is always a mathematical accounting between loss and gain making total angular momentum always whole and relatively constant? This strict accounting of the Earth's angular momentum regime is questionable.

Varga and Denis (1990) in discussing long-term deceleration and variations in length of day (LOD) point out that imbalance in the conservation of angular momentum may arise from factors other than tidal torque.

> "Imbalance can also arise if the Earth as a whole does not rotate as a solid body."

These factors include the "exchange of angular momentum between mantle, core, oceans and atmosphere rotating at different speeds."

This problem was addressed, also, by Brosche and Sunderman (1990) in discussing —"A Leak for the Angular Momentum of the Earth-Moon System." They point out that angular momentum lost from Earth's rotation consists of two transferable components: 1) that transferred to acceleration of the Moon in its earth orbit and, 2) and that of the Earth's "self acceleration" in its solar orbit. A third part of momentum loss is hinted at, but, not discussed.

Ratios of average Lunar/ Solar tidal torques published by Munk and MacDonald (1960), Bursa (1987), and Lambeck (1980) give k ratios ranging from 4.6 to 5.1. That attributes about 19 % to 22% of retarding torque to the Sun. Other values cited by Brosche and Wunsch (1990) place the average negative torque k value at 8.16, ----or, the solar torque at about 12%. They go on to state:

> "If there are non-tidal changes (Wnt), e.g., by non-tidal torques or as reaction on a changing moment of inertia ( ) of the Earth, they have to be added. The sum (of total angular momentum) can then be confronted with a directly observed value (W) for the Earth."

Wtl + Wts + Wnt = W (1) Brosche & Wunsch

(W is Omega)
= angular velocity in Radians /sec

This author interprets the forgoing as supporting a view that the Earth is losing angular momentum that is not presently observable or calculable directly. Acceleration of the moon in its orbit is, of course, measured regularly by Laser. Earth's acceleration in its solar orbit must be minuscule.

This leaves open to speculation, the possibility (probability) of a significant loss in Earth's angular momentum that we are unable to directly measure although the source of the loss would seem apparent. Brosche and Wunsch (1990) termed this unknown factor a "leak."

It is postulated by most seismologists and geophysicists that Earth has a substantial volume or belt of internal liquid (or plastic) mantle. As the Earth rotates, any such mobile material is subjected to the gravitational effects of tide and the centrifugal force of rotation. Any differences in density due to temperature or layering irregularities will result in motion of some degree, the direction and magnitude being unpredictable. Additionally, even if such a zone of liquid were spherically symmetrical, there would be lateral movement akin to tidal motion. The same tendency would occur, to a lesser extent, in large mobile diapiric bodies. e.g. batholiths, laccoliths, and large basaltic "magma chambers.".

In all of these cases, the motion of actual liquid, or the creep of plastic material, would involve internal friction and the generation of heat. Or, stated differently, the kinetic energy induced by internal tides would convert into thermal energy. This is amply demonstrated on Jupiter's moon Io, though its deformation is not from "tides" due to rotation.

Murray and Dermott (1999) in Solar System Dynamics, p 160, state:

> "So far we have assumed that the energy of the (Earth) system is conserved. However, in practice, tidal oscillations always generate friction and this results in energy loss and a phase shift in the tidal response of the planet."

It is clear that in dealing with Earth-Moon tidal forces; there is not a clean transfer of angular momentum from earth's deceleration to the Moon's orbital acceleration. Some part of angular momentum loss is transferred, but, not all.

This leaves us with a difficult problem. The amount of angular momentum appearing as Lunar acceleration is calculable. But, the amount of loss to Earth's solar orbit, and the loss to creation of thermal energy within the Earth would only be guesses.

Earth's internal body tides create distortion and friction that convert mechanical energy into thermal energy. This loss will not be "transported" to another body to maintain the principle of the conservation of angular momentum. While the proportion of this internal loss relative to the total loss of angular momentum is probably small and impossible to calculate, it may, non-the-less, be of major significance in attempting to resolve a history of Earth's rotation and the Earth- Lunar relationship over geologic time.

This situation leaves open the probability that earlier in Earth history, the factors involved in the Earth's angular momentum loss were similar but different in magnitude.
Assume that one billion years ago, there existed the same tripartite division in the Earth's l

angular momentum to tidal torque. At this time, the earth rotated at a higher rate and the Moon's orbit was closer. One part, (Wtl), the largest, transferred to the Moon's orbit. A second part (Wts) transferred to the Earth's own solar orbit, and a third portion (Wnt) was dissipated into thermal energy by internal friction. Formula (1).

But, consider how the geometry at that time would alter the relative proportions of those three allocations.

1) The moon was closer to Earth creating greater tidal forces in the form of higher tides in the oceans and stronger internal body tides.

2) The lunar tides were stronger than the Sun's induced earth tide (which has remained unchanged) therefore, the Sun-Earth-tide's share of total momentum loss was less, while the Lunar tide's share was greater.

3) Stronger tides, both aqueous and Earth's internal body tides due to closer lunar proximity would be more intense; therefore, the amount and relative share of momentum loss from dynamic energy converted into thermal energy would be greater.

4) The Earth's faster rotation at that time also means that the <u>rate</u> of momentum loss extracted by tidal torque was greater.

If these four factors are correct, they lead to the following conclusions.

* At least as far back as two billion years (and more), the Earth-Moon twin planets interacted to influence the other's dynamic motions.

* Earth rotated more rapidly but was decelerated by tidal torque imposed by the Moon, internal body tide effects, and the Sun.

* The transfer of angular momentum from Earth's rotational deceleration to acceleration of the Moon's orbit was greater in the past when both the tidal amplitude and the phase lag angle were greater than they are today.

* The loss of angular momentum to thermal energy was greater in the past than it is today and this <u>portion</u> of momentum loss relative to the total was greater.

It is reasonable to speculate that within Phanerozoic time both the Earth's rotation and the Moon's orbital rate were greater than has been suspected. It can be shown that both of these factors may be moderately increased without negating the evidence provided by the growth rings on Phanerozoic marine fossils.

*   *   *   *

6.4 Tidal Torque and Variation in Phase Angle

As explained previously, the tidal *phase angle* is a measure of the angle between lines drawn between the crest of the tidal bulge, the Earth's center and the Moon's center. This average angle has no doubt varied through geologic time. The angle also varies within the period of a lunar (synodal month).

The latter variation arises from the fact that while the tidal forces imposed on the Earth by both the Sun and the Moon remain essentially constant during a lunar month, their combined effects do not.

The Sun's tidal force and the tidal bulge that would result if the moon did not exist would remain essentially constant throughout the Earth year, so would the phase angle (excepting the Earth's elliptical orbit). Now, consider the moon's influence separately without the sun. The Earth's tidal bulge and phase angle would remain constant during the Moon's monthly orbit, but, the fact is that the tides and tidal bulge do not remain constant through a monthly Lunar cycle, (synodal month).

B

A

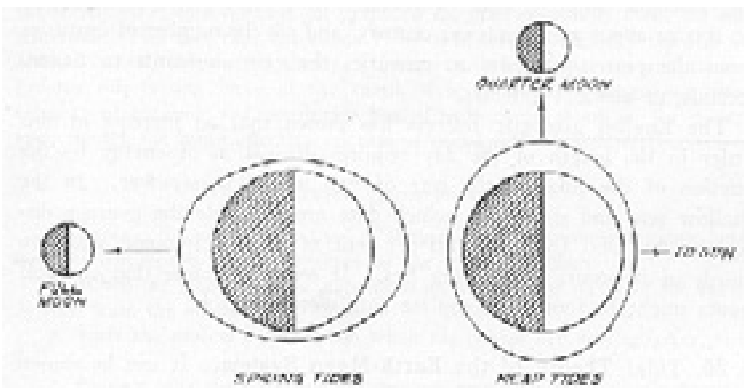


Fig. 6.1.4 Spring Tides and Neap Tides. Spring tides occur at new and full moon when lunar and solar tides reinforce each other. Neap tides occur at quarter moon when one set of tides is partly neutralized by the other.

When the Sun, Moon, and Earth are all in line, tidal forces are additive, increasing the deformational bulge to cause maximum (spring) tides (position A). The larger deformation means more time is required for the Earth's elastic bulge to return to normal. The phase angle effect is, thereby, temporarily increased.

When the Moon is in position (B) (neap tides), 90 degrees from the line between Sun Earth, the Sun's tidal force reduces the Moon's effect on tidal bulge. Since the tidal bulge is smaller, less deformation means less time is required to bring the deformation back to normal. Consequently, the effect of Phase angle is reduced. Thus, during a lunar month, at least three factors interplay to
alter the level of tidal torque imposed to retard the Earth's rotation and its reciprocal torque (accelerating) the Moon's orbit:

(1) The Earth's rate of rotation
(2) The distance between the center of mass in the Earth's elevated tidal bulge and the center of the Moon.
(3) The phase angle effect.

It is important to point out that the Moon does not impose its will on the Earth without effect on its own condition. The tidal bulge on the Earth and the fact that it constantly is in a position ahead of the line drawn between the center of the Earth and the Moon means that the bulge has a greater gravitational attraction for the Moon than points at lesser angles, or distances behind the line of centers. The larger the phase angle, the greater will be the effective mutual torque imposed on both the Earth and the Moon. We will return to this later when discussing continental drift.
Consequently, the Earth's tidal bulge imposes a retarding torque (*tidal friction)* slowing the Earth's rotation and a torque on the Moon accelerating the Moon in its orbit. The effect of this acceleration causes the Moon to increase its orbital velocity and its orbital radius. This increase in radius, determined by laser measurements from reflectors placed on the moon by our astronaut teams, has been measured at a present rate of about 3.3 centimeters annually. That is to say that the torque imposed on the Moon by tidal effects under current conditions is causing the Moon to move away from the Earth at that rate.

With the forgoing in mind, one quickly comes to the question of how close the Moon might have been in the past. If we use a rate of recession pegged at 3.25cm per year (back-tracked) we find that the Moon would be orbiting as follows:

Time Before Present	Approx. Orbital Distance
Present	237000 miles
1000 Ma	216800 "
2000 Ma	200650 "
3000 Ma	176400 "
4000 Ma	156200 "

These figures do not appear to be extreme, and may be conservative. What is apparent, however, is that tidal conditions on the Earth would have been far different in the past than they are today! The Lunar recession rate would not have been constant, and an average figure was probably greater. While we are now within the realm of speculation, it is reasonable to believe that:

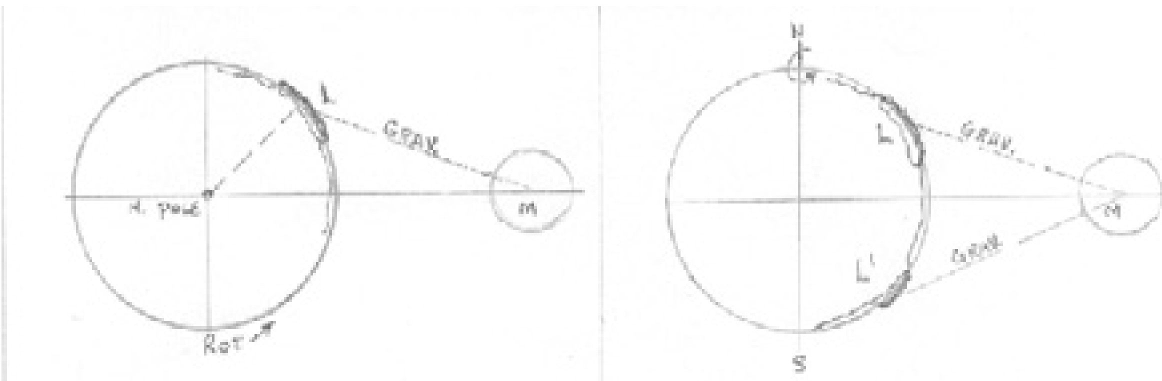
a) Compared to the present, Earth tides were increasingly more severe the farther we look into the past.
b) The phase angle was much greater in the past.
c) The mutual accelerations (torque) imposed on the Earth and the Moon were greater in the past.
d) The Moon may well have been closer to the Earth than the projected regressions calculated above indicate.
e) The Earth's rate of slowing was substantially greater in the past yielding a considerably shorter day than is suggested by current data.

6.5 Earth's Axial Precession

Possible Mechanism to Cause Earth Axial Precession

Figure A (plan view) Figure B (elevation View)

Figure 6.5.1



The Earth is a huge gyro freely rotating in space. In this sense it is governed by the same physical laws and the basic principles governing all gyros.

1) The axis in any rotating body always passes through the center of mass however that mass may be distributed.

2) A spinning gyro, in following Newton's first law of motion, persists in its state of motion (position) unless acted upon by an external force.

3) When an external force is applied, the axis of the gyro reacts by tilting (precessing) in the direction of the applied force at a point 90 degrees from the point of application in the direction of rotation. This displacement, or precession, is a function of the gyro's mass, its angular momentum, the magnitude of the force applied, and the length of time it is applied.

4) In Fig. B above, L and L' are hypothetical landmasses periodically facing the Moon as the Earth rotates. L is larger in size and mass than L'. Each is the same elevation and the center of each continental mass is equally distant north and south of the equator.

5) In the illustration, both L and L' are equally distant from the Moon

6) Since the accelerating force of gravity between two objects is a function of their respective masses and separation, it is obvious that the attractive force between the Moon and landmass L is greater than that between the moon and L'. There is, therefore, an imbalance yielding a gravitational force vector at L directed south toward the equator.

The net force vector at L would be even larger if L' were offset in longitude, or did not exist at this point in time.

7) It is the gravitational force vector generated between L and the moon and directed southerly which is now the <u>external force</u> being applied to the "Earth gyro" tending to cause the north polar axis to tilt (precess) toward a point 90 degrees (in the direction of rotation) backward from the plane of the drawing.

Such external forces generated by the Moon, if applied over long periods of geologic time, will cause the axial pole to shift. Or, as it has been referred to in the literature, it will "wander." If this process is considered along with the concept of continental drift, which the author believes may be driven by the same basic Moon generated gravitational force,(discussed elsewhere) it will be seen that the displacement (drifting)of continental land masses may serendipitously move to positions where the masses located north and south of the equator will be in balance. At this point, precession and polar axial shift from this cause will cease, although other factors beyond the scope of this discussion can cause minor shifts and "wobble." The Earth may be at, or near to, such a neutral condition at the present time.

While Figure B illustrates how Earth-axial precession may be induced, it is apparent that the geographic <u>distribution</u> of continental masses relative to the Earth's existing equator is a controlling factor which will effect the final net result. For example, as the Earth rotates each day, there may in the past, have been landmasses in the southern hemisphere at different longitudes which would generate net vectorial forces tending to reverse the precessional effect in the illustration above. These conflicting effects could occur several times in the course of a single Earth rotation. Through a rotation of 360 degrees, it would be the <u>net</u> precessional force that prevailed. This is a process that can, and probably has, produced major "permanent" polar shifts in the Earth's past history.

It should be mentioned that Earth's axis is presently inclined 23 ½ degrees to the plane of its orbit and the equator is inclined 5 degrees to the plane of the Moon's orbit. Due to the Earth's equatorial bulge, the Moon's gravitational attraction exerts a force tending to pull the bulge into the plane of its orbit. But, since the Earth reacts like a gyroscope to this *externally applied force,*
The result is a cyclic precession of the Earth's axis. This may cause the observed conical or circular motion around Polaris, our pole star having a period of 26,000 years.

*   *   *   *

7.0 GRAVITY AS A FACTOR IN TECTONICS

7.1 Introduction

A number of authors have considered gravity as a factor in tectonic processes. Sanchez Cela 1990, cites several authors who consider external celestial sources as influencing geological cycles through changes in the Gravitational Constant. (i.e. Steiner 1967, Machado 1967, Tamarazan 1967, and Benko 1985) These suggestions largely relate to the position of our solar system traveling through the Milky Way Galaxy over hundreds of millions of years. Others cited related changes in (g) and certain cyclic geologic phenomena to the expansion of the universe theory, changes in distance between Earth and Sun, Earth radius, etc., Zaykov 1979, Benko 1985, Kropotkin 1979, Salop 1983, etc.

Sanchez Cela also briefly considers Earth-Moon gravitational phenomena (tides), but, (sadly) in the end he concludes that these cosmic-solar-moon gravitational energies are "very minute in relation to the energy released in the geological phenomena." He then offers the thought that these gravity forces could "activate" and then "trigger" the great internal energy stored in the earth, ultimately attributing the forces in the Earth's crust and mantle to crystalline, chemical, and phase change phenomena. He, like many other authors, seems to hold internal thermal energy as the ultimate tectonic force yet he ponders how this internal energy can be released in apparently cyclic fashion. In the process he and others discard the potential of the tremendous dynamic forces unleashed by the Earth's constant increase in net gravity as the Earth slows in rotation, thereby reducing an opposing centrifugal force.

Gravity is the most fundamental fact of Earth science. Gravity is not an idea, an opinion or a theory. It is an immutable fact that men cannot vary, control or disregard. We can measure it, observe its effects, and define it mathematically. Gravity exists throughout the universe.

Gravity is the focal point on which all dynamic processes affecting the earth are centered. There is no dynamic process involving motion or the flow of energy totally divorced from the influence of gravity. Without gravity there would be no erosion, no ocean currents, no weather, no volcanism, and no sustained heat flow. There would be nothing but immobile dead mass—including no life. All of this sounds so elementary, so fundamental, like grade school science that the reader may be thinking, "get on with it!"

Yet, as obvious and irrefutable as these related facts are, Earth Scientists of all stripes have, for generations, marched through a vast field of dynamic effects making observations collecting data creating hypotheses, and theory after theory in attempting to understand and explain these effects, all the while deftly avoiding the fact that gravity is the overlord to all dynamic processes and the ruler to which all other effects owe fealty.

In extremis, *gravity* is the one basic force operating on the Earth's surface and within the mantle for which the limits of power and force are essentially *without* limit. This is ultimately the power to elevate and depress continents, form ocean basins, and to crush thick rigid crustal plates generating jumbled elevated chains of folded, faulted, and rheomorphically metamorphosed rocks extending tens of thousands of kilometers across every quadrant of the Earth.
Beloussov (1962) seems to have come closest (among writers reviewed) to recognizing gravity

as the primary source of energy effecting "displacements of material that causes changes in the Earth's structure----"
He lists four principal source possibilities in this order: 1) gravitational energy, 2) rotational energy, 3) chemical energy, or, energy of crystallization, and, 4) thermal energy. Gravitation's potential energy, he states, "has repeatedly been indicated as the cause of tectonic movements."

> "There is convincing evidence in geological and geophysical data that the main process at depth of fundamental significance in tectonics is the differentiation by density of material in the crystalline shell, with the denser substances sinking deeper and the lighter "floating to the surface."

These words come very close to describing this writer's concept of *gravitation density cells* discussed in Section 9.0. Beloussov concluded that rotational energy "must have some influence on tectonics", but, thought its role was probably very small—and in the way he visualized this, he was correct. Unfortunately, Beloussov did not connect the Earth's rotational deceleration to its effect on gravity, and the role that changing gravity plays in crustal processes.

7.2 Defining Gravity

Gravitational attraction between two masses, M1 and M2, is defined as a force equal to

$$\frac{M1 \times M2 \times G}{d^2}$$

(G is a universal constant) divided by the square of the distance between them.

On Earth this is expressed as the force of acceleration acting to attract a unit of mass at the surface toward the Earth's center of mass. This may be designated as a vector arrow directed toward the center of the earth. Due to the earth's rotation there is a countervailing (centrifugal) force vector oriented 180 degrees opposite to gravity acting to reduce the value of gravity. The magnitude of this centrifugal force is a function of the rate of earth's rotation.

At the equator the present value of acceleration (g) is about 980.04 centimeters /second /second. Acceleration at the north pole (90 deg. Lat.) is 983.21 cm/sec/sec. i.e. the weight of an object at the pole is heavier than the same object at the equator. The difference between polar and equatorial (g) values results from two factors: a) earth's polar radius (distance) is less at the pole than it is at the equator due to earth's oblateness, and b) centrifugal force (Fc) at the pole is nil while Fc reduces (g) at the equator. This brings us to a need to recognize and discuss the difference between *static* gravity and *net* gravity.

7.3 Static Gravity and Net Gravity

Static gravity in simple form is the attractive force between two bodies based on their respective unit masses and the distance between them. Actual values at different locations on Earth are dependent on variations in crustal density distribution, and changes in radius. For practical purposes in this discussion, we take static gravity (g) as dependent only on the values of mass and geometry in the absence of Earth rotation.

Net gravity is defined here as measured (or calculated) gravity adjusted for the centrifugal force of earth's rotation as it changes through geologic time. Since Fc acts 180 degrees in opposition to static gravity, this means that effective *net* gravity was less when Earth's day is projected to be shorter ---- perhaps ten hours or less in the Archean---- and that *net* gravity has been (and is) slowly increasing as Earth's rotation and reduction in centrifugal force diminish in response to negative tidal torque and internal friction.

It is now apparent that the figure of 980.04 cm/sec/sec at the equator incorporates this centrifugal force effect and is, therefore, a *net gravity* value, while the polar figure of 983.21 cm/sec/sec is
a static gravity value. It is realized, also, that in models projecting higher rates of rotation in the geologic past, *static* gravity values would also change (increase) over geologic time due to a reduction in oblateness giving a reduction in equatorial radius. Additionally, there would be an over-all reduction in radius and Earth volume due to slowly increasing net gravity for Earth's entire surface. These values are not presently available to the author.

7.4 Crustal Effects of Increasing Gravity

The Earth is essentially a *closed body* of finite volume, seeking stability under existing gravity conditions, but ever restless as gravity changes. Considered as a whole, an increase in net (*g)* value will increase the weight of all components from the surface to an indefinite depth level internally. This will increase internal pressure at all depths resulting in an increase in internal density and reduction in Earth's volume. These changes force a reduction in surface area, produce tangential compression and other orogenic mechanisms in the crust.

Consider also, the effect of increased gravity on continental and oceanic plates whose densities average about 2.7 and 3.1, respectively. Assume hypothetically that, initially, these crustal segments are in isostatic balance. As gravity increases, the effective weight of both will increase. An oceanic slab, having greater unit mass will press harder on the substrate than will a continental slab of equal thickness. Beneath the comparatively thinner oceanic crust is mantle of still greater density (>3.6). At some depth level there will be a level of matching mantle beneath the thicker continental slab. Measured from the surface to this matching depth, the average density of the ocean crust (+) mantle will be greater than the average density of the continental slab(+) mantle, therefore, pressure under the ocean crust will be greater and force a lateral flow of substrate toward lower pressure under the continental slab.

Under these conditions, the oceanic slab will always subside. The continental slab may subside, remain fixed, or elevate, depending upon the relative thicknesses and the actual density values of each. Since the Earth is essentially a closed vessel, the result of an increasing gravity over long periods of time will be that areas of dense oceanic crust will subside relative to the continental crust. Areas of continental crust varying in density and mass will also be subject to the effects above, and may also shift vertically relative to each other and to crustal blocks adjacent.

The end result of increasing gravity over periods of geologic time will also be influenced, *pari passu,* by other tectonic processes; including: tangential compression, epeirogeny, local rifting, erosion, and volcanism, trench formation, and possibly drift.

* * * *

8.0: GRAVITY vs. WEIGHT INCREASES

The following selected examples and plots demonstrate the effects that changes in the rates of Earth rotation have on different volumes of the crust as a function of time and variation in rock density.

Average densities of 2.7 for granite and 3.0 for basalt were used as these are commonly accepted values for continental crust and oceanic crust.

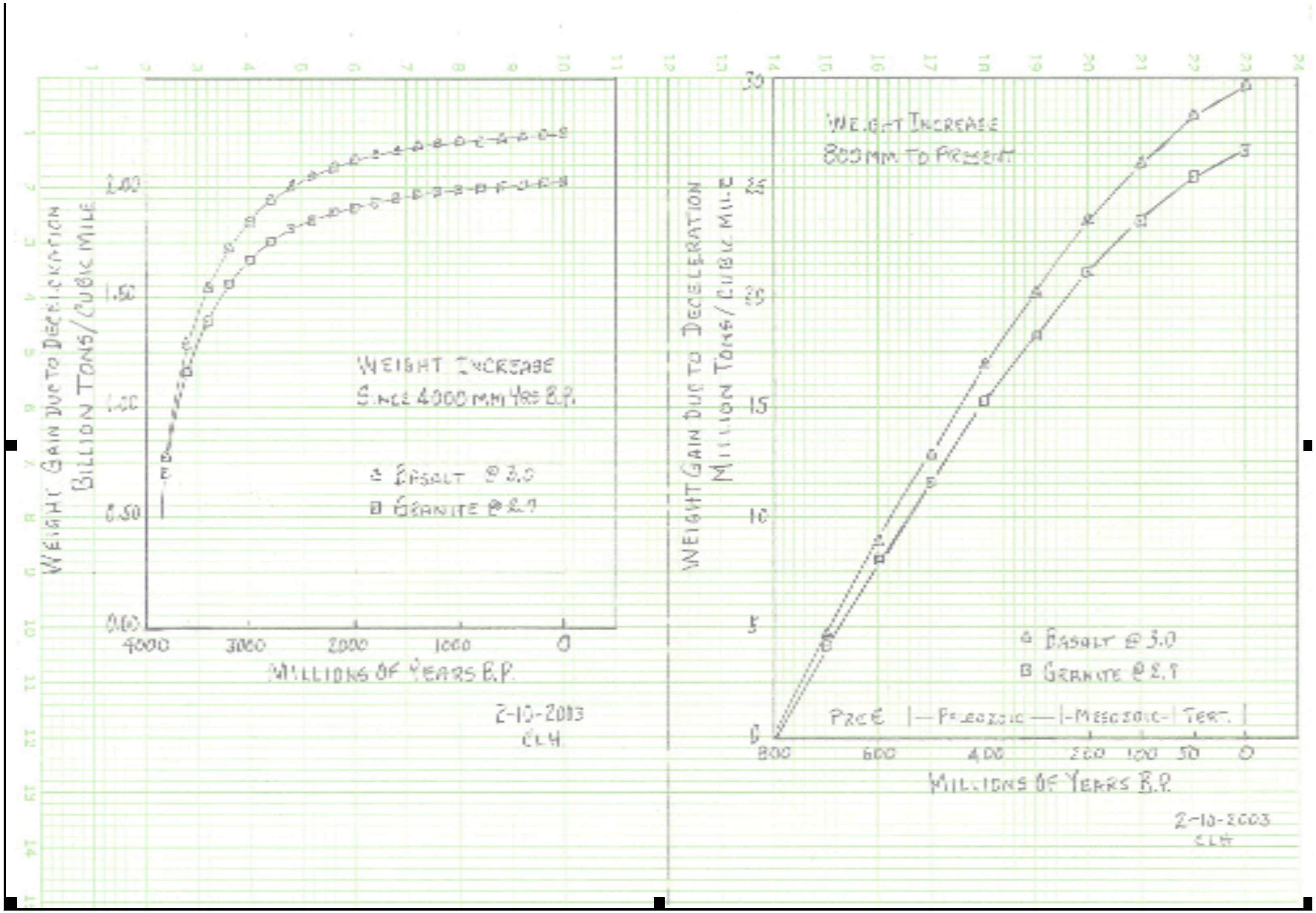
Different time periods were used and the lengths of Paleo-days were varied to model and evaluate projected rates of deceleration.

All values (except the first example) shown for net gravity reflects the effect rotational change has on weights AT THE EQUATOR. The figures given can easily be corrected to give values at higher or lower latitudes by using the cosine of latitude, but this would not change the fundamental principles and conclusions the author hopes to demonstrate.

Please note that a daily deceleration of only 1.0 second (over 58,823 years at the present rate) may have significant effects on crustal forces.

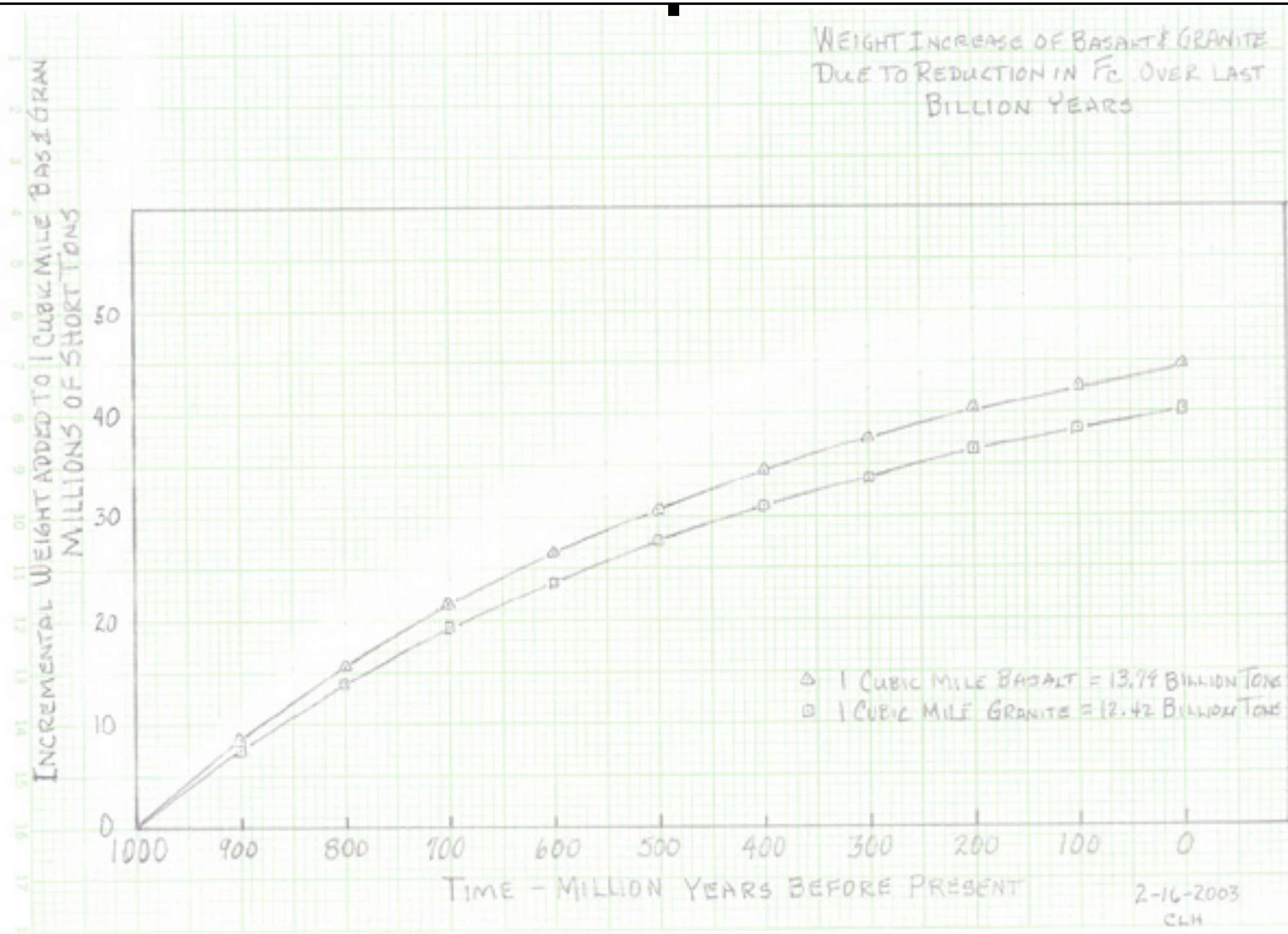
*   *   *

CHART 8.1A



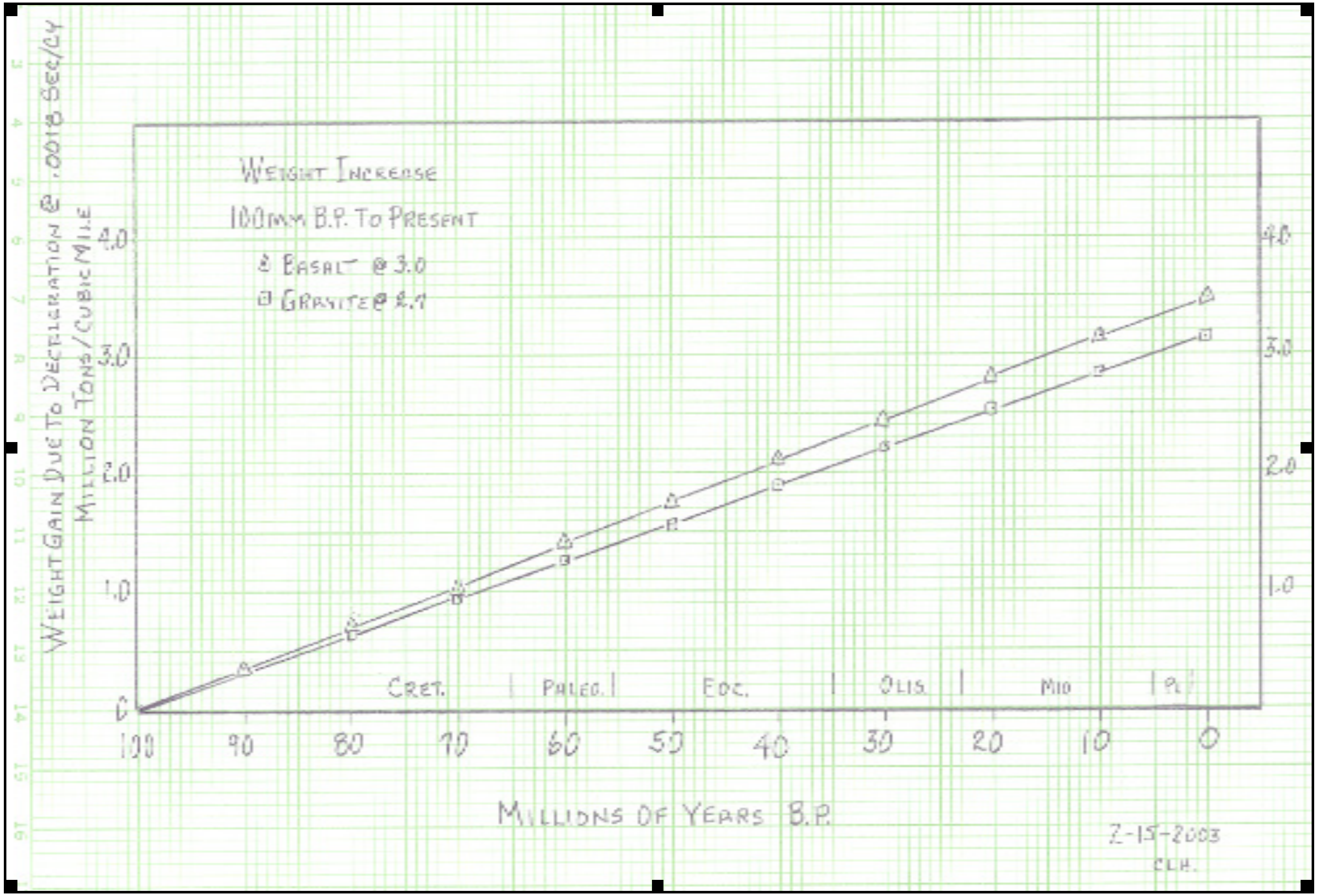
WEIGHT INCREASE
SINCE 4000 MM YRS B.P.
WEIGHT GAIN DUE TO DECELERATION
BILLION TONS/CUBIC MILE
2.00
1.50
1.00
0.50
0.00
4000
3000
2000
1000
0
MILLIONS OF YEARS B.P.
BASALT @ 3.0
GRANITE @ 2.7
2-10-2003
CLH
WEIGHT INCREASE
800 MM TO PRESENT
WEIGHT GAIN DUE TO DECELERATION
MILLION TONS/CUBIC MILE
30
25
20
15
10
5
0
800
600
400
200
100
50
0
MILLIONS OF YEARS B.P.
BASALT @ 3.0
GRANITE @ 2.7
2-10-2003
CLH

CHART 8.1B



Weight Increase of Basalt & Granite Due to Reduction in Fc Over Last Billion Years
Incremental Weight Added to 1 Cubic Mile Bas & Gran
Millions of Short Tons
50
40
30
20
10
0
1000
900
800
700
600
500
400
300
200
100
0
Time - Million Years Before Present
1 Cubic Mile Basalt = 13.79 Billion Tons
1 Cubic Mile Granite = 12.42 Billion Tons
2-16-2003
CLH

CHART 8.1C



WEIGHT INCREASE
100MM B.P. TO PRESENT
BASALT @ 3.0
GRANITE @ 2.7
WEIGHT GAIN DUE TO DECELERATION @ .0018 SEC/CY
MILLION TONS/CUBIC MILE
4.0
3.0
2.0
1.0
0
CRET.
PALEO.
EOC.
OLIG.
MIO
PL
100
90
80
70
60
50
40
30
20
10
0
MILLIONS OF YEARS B.P.
2-15-2003
CLH.

9.1 Introduction

Extensive oceanic ridges postulated as “spreading centers” are attributed in the Plate Tectonic hypothesis to thermal convection plumes emanating from heat sources deep below the lithosphere. Presumably similar thermal convection plumes have also been feeders for the tens of thousands of volcanic peaks populating the oceanic basins and for the extensive basaltic flows which have repeatedly paved these basins to unknown thicknesses.

In the author’s view, “convection cells” in the oceanic crust from which magma may erupt are not due to convection as it is normally thought of and experienced in observable circumstances.

While there may be localities of molten material within the oceanic crust, the mechanism of rise is due to the differential between hot material of low density and laterally surrounding cooler material of greater density.

It will be immediately argued, that this is merely a different way of describing a thermal plume in the presently accepted form. There is an important difference in concept, however, when examining the physical environment in which thermal cells are said to function. This difference lies in the source of the dynamic energy providing vertical lift.

In conventional thinking, thermal cells, whether in a pot of soup or in a conceptual environment of sub-crustal oceanic convection cells, the density differential is created by a supply of heat. This heat expands the magma or plastic material creating differences in density to propagate the cell’s motion in a field of constant gravity. By this thinking these cells are generated and maintained by localized temperature differences emanating from a lower, (usually disparate) heat source. If the heat source diminishes or dies, the tendency to rise also ceases.

9.2 Gravitation **Density Cells** (An alternative to thermal convection)

In this concept we consider the increase in net gravity due to Earth’s deceleration over geological time. The vertical force generated by a localized density differential ($f = mg$) does not depend on the input or maintenance of heat energy. Rather, it is increasing gravity imposed on the density differential between two different materials that creates a pressure difference driving the lighter material upward. This condition can exist even after magma solidifies depending upon the density relationships affected by steadily increasing gravity. Thus, it may be that granitic mountains with deep roots continue to be uplifted millions of years after initial emplacement.

Now examine the function of *Gravitation Density Cells.* Assume that throughout known geologic history, Earth has decelerated, centrifugal force has diminished, and net gravity has slowly increased thereby increasing the weight of all rocks in the crust, mantle, and asthenosphere. In those rocks of similar composition, but of slightly different densities induced by variations in temperature, the weight differences are exacerbated as net g increases. There were, in addition to temperature variations, density differences due to composition (and perhaps changes in physical state or crystal structure). These combined effects on differences in weight became ever greater as g increased.

Lateral temperature differences occurring at a crustal depth otherwise in hydrostatic equilibrium, can result from radioactive decay, tectonic motion, or heat transfer from depth. These source factors, while a part of the mechanism are not elemental to our concept.

9.3 Discussion of Density Cells

All rocks will increase in weight as gravity increases. Hotter materials (molten, plastic, or solid) of less density increase *less* in weight than cooler, but more dense materials nearby. In an environment of uniform lateral static pressure, the colder, heavier, more dense, material will tend to sink while the lighter material, though also made heavier by increasing gravity, will be displaced upward. Thus, conceptually, it is the long-term increase in gravity which drives the mechanism and not localized or regional heating from below. This is a significant difference.

Absent this concept of slowly increasing gravity, the rise of magma within the crust is dependent upon thermal forces (i.e. convection) to drive its movement, especially in the case of sialic magma.
Under constant gravity the movement of rising magma could quickly reach an equilibrium point or “roof” unless additional thermal energy is supplied from a deeper source—along with an additional volume of material — in other words, from convection currents— to supply and drive on-going vertical movement. This is not a requirement if increasing gravity is the driving force. An increase in gravity will raise internal pressures to supplement pre-existing vertical driving forces.

Based on recent studies utilizing seismic tomography (Dziewonski and Woodhouse 1984) and (Dziewonski 1987) have cast doubt that convection currents exist in the mantle.

This constraint applies whether movement is dominantly vertical in the form of diapirs of varying geometry, or if the diapirs develop in consort with subsidiary lateral injections along planes of weakness to create sills, laccoliths, or batholiths. A slow increase in gravity over long periods of geologic time can create these structures from an original finite magma source without recourse to deep convection currents.

In similar vein, Beloussov (1962) offered a comparable argument for the role of crustal density differences in tectogenesis----but absent any suggestion of changing gravity as a trigger or primary driving force.

> “There is convincing evidence in geologic and geophysical data that the main process at depth of fundamental significance in tectonics is the differential by density of material in the crystalline shell, with denser substances sinking deeper and the lighter “floating” to the surface.”

Recognizing the fundamental role that gravity plays in tectogenesis in its many forms and processes, perhaps a more realistic term for “convection cells” would be ***gravitation cells,*** or ***gravitation density cells****.* This conceptional mechanism would lend far greater understanding to the linearity of the mid-ocean ridges (also misnamed) and the long straight or gently arcuate boundaries of the oceanic plates created by shear stresses in movement between major plates in a generally consistent field of compressional stress.

We may add further clarity to the concept of gravitation density cells by the following analogy:

Think of the thinner, more dense, crust of the ocean basins as a frozen crust covering huge ponds of mobile material flanked by continents. The continents stand higher because they are composed of less dense (granitic) materials. Both the continents and the oceanic crust overlie elastic, probably molten, material at depth.

At a given period in time the continents and the oceanic crust are in "isostatic" equilibrium for the masses, densities, and mechanical strengths existing in their regional stress fields. They stand at their respective elevations in a field of gravity to which both are being subjected equally.

Now, visualize that with the passage of time there is a slow increase in the value of *net gravity*. Both the basaltic rocks in the oceanic crust and the granitic rocks of the continents become slightly heavier. But because the basalt is more dense (3.0 to3.2 vs. 2.7), the weight increase in basalt is greater.

Thus, there is an increasing weight imposed by the dense, frozen, oceanic crust on the mobile material beneath it. Similarly, the continents become heavier and press down more as well; but, on
a volumetric and unit area basis, the weight is less. The crust on the oceanic "ponds" tends to sink exerting basin-wide downward pressure. Since the Earth is essentially a closed spherical vessel, internal pressure on the mobile deeper zone will also increase. The oceanic crust, being wrought with fractures and zones of weakness, allows molten material (magma) to rise, thereby feeding the volcanic activity we observe along mid-ocean ridges, fracture zones, and elsewhere in the crustal complex.

These zones of weakness result from ruptures created by compressive shear stresses, and at times, from tensional stresses induced by the jostling of crustal segments having different mechanical strengths. (The structural construction of the major "mid-ocean ridges" whether the result of compression or tension is discussed later).

On a localized basis, the rise and eruption of magma can be thought of as driven by the effects of slowly increasing gravity on differences in density induced by temperature and composition. On an overall regional basis, however, the process can more accurately be described as being driven by gravity induced pressure differentials below materials of different relative densities due to their composition and thermal state. Volcanic zones such as sub-sea volcanic peaks, island arcs, and particularly ocean ridges characterized by volcanic activity may, therefore, be thought of as being fed by **gravitation-density cells.**

Like many ideas an author may believe to be original, a review of related literature often reveals earlier seeds of thought planted by others before him. A similar threshold of thought was crossed by S. Warren Carey (1976) in a paper proposing a hypothesis of earth expansion.

> "The Russians and many European geologists have long recognized that orogenesis is a diapiric, gravity driven process, in a dialative environment, in which the upper part of the rising tumor spreads laterally under its weight...".

And again, Arthur Meyerhoff, et al (1992) in discussing Tectonics Of The Ocean Basins, refers briefly to much the same conceptual process:

"The magma apparently is generated from an ultra-mafic parent in the asthenosphere where it is gravitationally unstable. Following the law of gravity----or more specifically, the Peach-Kohler climb force (Weertman and Weertman, 1964; Gretner, 1969; Weertman, 1971)--- the basaltic magma rises beneath the mid-ocean ridge until it is in equilibrium with its surroundings (that is, where the density of the basalt equals the density of the surrounding lithosphere), as outlined in detail by G.K. Gilbert (1887). At the level where the magma is in equilibrium with its surroundings—Walker (1989) called it the level of neutral buoyancy— the magma spreads laterally, forming a giant sill or laccolith-like body (Krylov et.al., 1979; Beloussov, 1980; Sychev, 1985)."

In a separate paper describing an hypothesis termed, 'Surge Tectonics', Meyerhoff, et al (1992) discuss "diapirs" and their role in the tectonic mechanism. They cite a number of other authors who have recognized geological, geophysical, and theoretical evidence found in tectonic zones in continental areas around the world. This *mantle diapirism,* as it has been called, often involves lower density, and low (seismic) velocity materials in fold belts, rift zones, and areas of uplift where it may form the cores of deformed and faulted areas in which the diapiric material has 'participated in the deformation'. Meyerhoff et al state that the weight of this evidence,---- "practically require(s) large scale, upper mantle diapirism as a part of the tectogenetic process."
This author does not accept "Surge Tectonics."

The concept of a gravitation density cell thus applies equally well both in areas of continental crust or in oceanic basins wherever the requisite differences in density are present. Absent previously is the concept of Earth deceleration resulting in a slow net gravity increase (as proposed herein) to the point where mobility forces "isostatic" and epeirogenetic adjustment.

This mechanism can, of course, initiate and operate in a stress regime dominated by either compression or tension. It is evident also, that the concept of gravitation density cells obviates the need for mantle convection as a feed for the hypothesis of mid-ocean ridges postulated as a source of material for new oceanic crust, and by extension, it eliminates the "conveyer belt" mechanism driving postulated new crust to its doom in a subduction zone, or to function as an agent in continental drift.

When this view of gravity driven mobility is adopted, it becomes immediately apparent that the **epeirogenic** elevation of continental areas and the subsidence of ocean basin floors result from a mechanism closely akin to the gravity induced forces discussed above. One might even call it isostatic adjustment on a grand scale. This will be discussed in more detail later. (Section 12.0)

The whole scene, of course, is more complex, as we are operating within an environment where other processes are also active and the effects of changing factors such as reduction of Earth surface area, the epeirogeny of deepening ocean basins and continental up-lift, and orogenic crustal displacement, influence the overall results. The question of continental drifting is a matter for separate discussion. It is worth stating at his point, also, that the existence of sub-crustal mantle convection, though widely accepted in theory, has never been proved by physical evidence.

In a critique of Plate Tectonics Skobelin,et.al. (1990) posed what he termed some critical questions:

"How does magma, formed as a result of partial melting and scattered in some volume in the mantle, leave this volume? How and where is that emptiness formed? Where does the magma go?"

Disregarding the problem of genesis, at least a part of the answer to these questions is provided by the concept of **gravitation density** cells.

Where mobile material is created, possibly by radioactive heat or other mechanism (take your pick), the liquid melt is less dense than the enclosing material surrounding it. Therefore, in a field of slowly increasing gravity, a pressure differential is created. This tends to displace the melt vertically, perhaps by stoping or channels created by faulting or both.

As a granitic melt, perhaps of batholithic dimensions, rises over millions of years, the surrounding more dense material will flow plastically, displacing and forcing the lower density melt to rise.
The slowly moving mobilization of the cooler "solid" rock, promoted by pressure differential and by compression, may be modified by recrystalization and other metamorphic processes. The "emptiness" suggested by Skobelin et. al. (op cit.) never forms.

* * * *

Revisions: 10-18-2001; 11-5-2001; 8-15-2002; 8-30-2002; 9-4-2002; 1-17-2003, 4-22-04

9.4 Gravitation Density Mechanisms

The geotectonic uplift hypothesis was formulated in the works of Scottish geologist James Hutton in the late 1700s. It was later expanded by Von Buch and Swiss geologists (Studer et al). This became the reigning hypothesis in geotectonics during the first half of the 1800s. The hypothesis postulated that the uplift and deformation of mountains were caused by the intrusion of igneous rocks intruded from below.

> "Magma expands and rises from the interior of the Earth and is intruded into the sedimentary rock that compose the outer crust of the Earth; up-turning the rocks it encounters in the course of its rise."

The above statement of a proposed mechanism for mountain building is not unreasonable for its time, but left open is a discussion of the forces causing the magma to rise.

Gravitation density cells propelled by slowly increasing gravity as the Earth decelerates may provide a better answer.

In a hypothetical area where we have heterogeneous material of different densities comprising a mobile (plastic) crust, these materials may locally, over millennia, if undisturbed, temporarily reach a state of isostatic equilibrium with respect to vertical forces imposed by gravity.

However, since we can comfortably assume that in overall aspect the Earth is constantly in a state of slow physical change due to a wide variety of causes, both internal and endogenous, i.e. shifts of mass from erosion, degassing, lunar tidal strains, and others, there is inevitably a time when every area on the earth's surface is subjected to disequilibrium. This may develop thermally, mechanically from nearby crustal rupture, tidal flexing, or a gradual accumulation of increasing gravitational force. At some point, the hypothetical area of equilibrium under discussion will be pushed beyond a strain point and motion of adjustment will be initiated.

How will this motion be initiated and sustained? It will be the forces imposed by gravity on materials of different density. Increasing gravity will change their relative weights under conditions of pressure at deep levels where magma or plastic mantle is in juxtaposition either laterally, vertically, or both, with more dense and heavier material.

Net gravity which, over an extended period has been increasing, causes the weight of all materials to increase--- both the less dense and the more dense--- but unequally. This disrupts the equilibrium under the pre-existing conditions (at depth) and causes the more dense material to sink thereby increasing pressures at that depth level and forcing the less dense material of lower relative weight to rise.

The material of lesser density may be of different elemental composition or mobile magma. As upward motion of the lighter material proceeds, its mobility may increase due to additional melting from reduced pressures; it will expand and rise to a level of equilibrium. In the process shallower crustal materials will be pushed aside or upward and be penetrated by stoping and dikes, or partially absorbed in the melt. In this way a granitic batholith may be emplaced.

The uplifted crustal surface regions, generally under compressional stress from an overall on-going reduction in Earth surface area, will end up with mountainous areas having cores of granite or gneiss, bordered by zones of schist and lateral fold belts.

This, of course, is only a part of the complex mechanisms in mountain building. Other factors developing linear trends are discussed later. (name the section or chptr.)

9.5 Density Cells and Hot Spots

Yellowstone National Park is regarded by some as an example of a “hot spot” beneath the Earth’s crust. Over the past two million years, the area has experienced three major cycles of uplift, including repeated volcanic eruptions and calderic collapse. Indications of uplift, quakes, and thermal activity related to the central caldera are still in progress. (Smith and Christiansen 1982)

Gravity contours and seismic travel times (op cit.) show some important relationships. A density model of the crust and upper mantle under Yellowstone shows a 30 Km column of material whose maximum density is 0.2 gram/cc less than the density of surrounding material. Beneath this upper column is a deeper column of material extending to about 100 Km whose maximum density is 0.1 gram/cc less than the laterally surrounding material.

While this may reflect material composition or thermal density differences, the relationship fits with what one would expect where a ***gravitation density cell*** is operational. Moreover, the density cell concept does not require a *fixed* heat source deep in the mantle; only a source of magma and a tectonically created path to the surface is required. The *fixed* “hot spot” concept requires that a path to the surface through a thick continental plate be created originally, then be continually renewed if the plate is postulated to be drifting.

But, whether one accepts or rejects the concept of mantle-fixed heat sources, the influence of gravitation and density as factors in “hot spot” eruption is hard to overlook.

* * * *

10.0 CRUSTAL COMPRESSION

10.1 Geogenic Compression

Compression on the Earth's surface is created universally over the entire geometric orb. Thus, in a sense, tangential compression is created in every unit area of the crust, large or small.

Geogenic compression resulting from a shrinking surface is generated in vectors of 360 degrees relative to any given geographic point. But, additionally, due to the geometry of diminishing oblateness and circumference, small east-west vectors of compression are added to the 360 degree vectors. This results from an overall viewpoint, in east-west vectors of compression that are slightly greater than the north-south elements.

This condition, far greater in magnitude in the past, has prevailed through most of Earth's history. At the same time there can be localized regions of apparent tension imposed simultaneously by differential movements between adjacent competent crustal segments. These are due in part to heterogeneity in the mechanical strength of different portions of the crust which result in a jostling of plate segments. Additionally, there are non-uniform forces created by drift tendencies in different regions of the continental crust. These may increase compression in some areas and diminish it in others.

It is realized, of course, that due to heterogeneity in crustal composition, and thus of strength, compressional forces will rarely be equal in all directions. Thus, the manner of reaction or relief from stress will vary due to mechanical strength factors, and possible unrelated extraneous forces which determine the final orientation of induced relief.

10.2 The Orientation of Crustal Deformation

The foregoing is only a part of mountain building mechanisms. We must now examine why a majority of Earth's major topographic features develop along distinct linear trends or semi-arcuate geometry. Review of a world map showing continental and sea-floor topography will quickly illustrate this verity.

Examples on continents are abundant: South America's Andean Cordillera; North America's Appalachians, Rocky Mountains, the Cascade and Sierra Ranges, and the Sierra Madre Ranges
in Mexico. In Asia, are the Urals, Caucasus, Zagros, Himalayas, and others. In NW Africa, the Atlas chain, and in Australia the Great Divide Range -----all are essentially linear.
Recognized ocean basin ridges are even more numerous: The mid-Atlantic Ridge trends through the North and South Atlantic for more than ten thousand miles. In the Pacific are the East Pacific Rise, the Hawaiian Island range, the Line Island sub-sea range, the Aleutian Islands,

Louisville Ridge and others too numerous to mention.

The world's premier example of linearity is the (sub-sea) Ninety East Ridge----straight as a string N-S along the 90 East line of longitude for 2500 miles. Also, nearly N-S, is Investigator Ridge (1100 Mi @ 98E long); and the Chagos-Laccadive Ridge (1600 Mi. @72E Long). In the northwest Pacific are the Emperor Seamounts (1,500 Mi @170E).

We must also include the nominally E-W straight crustal schisms such as the Murray, Clarion, Clipperton, and Menard "fracture zones" in the Pacific. These and others persist, unbroken, for upwards of two thousand miles. Plus, the major deep trenches on three sides of the Pacific Basin, and the thousands of un-named "transform faults" offsetting the mid-ocean ridges in the Atlantic and Indian oceans. All of these----every one----is of distinctly linear configuration or partially arcuate.

A notable characteristic of compressional tectogenesis is the dominance of generally north-south orientation. There are, of course, many deviations; among them the nominally E-W oceanic fracture zones (Fig. 10.3.1) and the Himalayan to Mediterranean crustal trend

But clearly something,--- some fundamental physical factor--- in the process of building mountains and other features of crustal deformation is driving the *linearity* of crustal deformation. Most of this major crustal deformation throughout the world falls dominantly within a few degrees of N-S. The mostly east-west orientation of the south Asian Himalayan-Mediterrean trend being one of the few exceptions.

How can mantle convection cells create forces to develop narrow mid-ocean ridges thousands of kilometers long where, it is said, new crust is created and carried off "piggy back" on currents of sub-crustal magma to subduction trenches where oceanic sediments are scraped away, incorporated with continental lithologies and compressed into linear mountain belts thousands of kilometers in length? That is hard to visualize. What mechanism controls the linearity of convection cells in the mantle?

10.3 Linearity In Crustal Deformation

Linearity in crustal rupture is more understandable if explained in terms of geometry. This view argues that crustal yielding occurs where the sum of maximum vector forces is focused.
A reduction in Earth's surface area results in horizontal shear vectors (dominantly compression) uniformly oriented around 360 degrees. This compressive force is supplemented by a reduction in earth oblateness which can add two additional force vectors:

1) An E-W vector set develops from a reduction in radius. When added to the 360 degree vectors above, the maximum compressional force becomes E-W wherein yielding gives preference to N-S orientation.

2) A lesser vector created as oblateness is reduced results from shortening in the length of pole to

pole arcs of longitude. This creates N-S compression. When coupled with N-S vectors related to reduction in surface area, yielding oriented E-W may result.

While geometry offers a reasonably sound explanation, when assuming crustal uniformity, other factors such as crustal thickness and density variations may account for deviations from the exact directions suggested. This is more in accord with actual observations. Extraneous factors, no doubt, play a role in linearity that may, forever, remain obscure.

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It is hard, also, to understand how, or why, compressional mountains form on the continental side of deep trenches when it is postulated that thin layers of basaltic crust plunge down a steeply dipping Wadatti-Benioff zone into the mantle to create deep focus earthquakes at depths as deep as 700 km---- a depth well below commonly accepted thicknesses for continental or oceanic crust (60 to 80 km and 5 to 9 km, respectively). How and why, also, are rows of volcanoes spaced at frequent intervals landward from trenches around the Pacific Basin, where they are located in folded mountain belts set back about 100 miles from the trenches, or perched atop crests of adjacent island arcs.

How do linear compressional mountain chains and ridges get built in this scheme of things?
Why are mid-ocean ridges not more abundant, especially in the Pacific, home to at least a dozen major trenches, said by “mobilists” to require feeding by spreading centers? Why, if controlled by thermal convection in the mantle are “spreading centers” not oriented more randomly? Where is the spreading center maintaining the Aleutian trench? Why are convection “cells” narrow and elongated instead of rounded or lacking in directional orientation?

These questions, for which Plate Tectonics hypothesis offers no answers, make it clear that the truth must be sought elsewhere.

Those who argue against compression versus tension as the major stress factor in tectonics often state that a “thin pliable” oceanic crust cannot transmit compressional stress over large distances ---and that, therefore, some other mechanism is or explanation is required.

This thinking tacitly assumes that a basic crustal driving force must be generated by some mechanism such as convection flow, ocean crust spreading, or continental drift. Allegedly, such a force would displace a crustal segment thereby generating localized stress that would transmit compression through the crust to points some distance away.

This forces us to address the question of how compression is generated ,and how oceanic crust in the process of being ‘subducted’ can transmit compression to a continental border where it can create folded coastal mountain belts causing significant uplift, while thinner and presumably less competent oceanic crust remains unfolded or unbroken by thrust faults. If it is argued that the oceanic crust is being carried “piggy-back” by laterally flowing mantle convection or, that the crust is sinking because it is cold and dense, we must still face the question of how a thin oceanic crust can transmit compression to the continental block without itself being deformed. The answer is simple: It can’t--- and there is no geologic evidence that this has occurred or is occurring.

The primary point is that compression generated by increasing gravity is universal. It is everywhere. It is the simple geometry of a semi-rigid outer shell adjusting to a diminishing internal volume under the effects of Earth's tidal deceleration. No other compressional sources from sea-floor spreading, "drift" or other endogenetic factors are needed to explain most of the principal force for building Earth's linear chains of mountains. It is, however, recognized that other forces can and do intrude to alter this basic regime. Among these are isostatic adjustments, mass shifting, epeirogeny, and Earth's slow precession. These processes are, however, only superimposed on the fundamental tectonic mechanism and do not alter the basic premises presented.

10.4 Some components of Compression: orig draft 4/19/00 Mod on 3/9/03

1) Increasing Earth density and the reduction of total Surface area due to rotational deceleration.
This is the major source of continuing crustal compression. These compression vectors have 360 degree orientation toward any given point on the Earth's surface without preferred orientation relative to latitude or longitude.

2) Reduction in oblateness: The principal oblateness component, oriented E-W, is due to reduction of Earth's circumference. This is maximum at the equator, diminishing to zero at the poles. A second factor are vectors of lesser amount oriented N-S. This slight compression is due to a reduction in distance along the lines of longitude between the axial poles.

These factors were of greater magnitude and affected compression more in the Proterozoic and the Archean when Earth's day is projected at less than ten hours. As the day lengthened to the present, Earth's oblateness has diminished —approaching that of a sphere where a further reduction in flattening becomes of minor geometric importance.

3) Effects of Lunar gravitational drag on the tidal bulge and elevated continental areas.
This vector of indeterminate force is asserted only in a westerly direction. It is maximum at the equator and diminishes toward the poles. Theoretically, it may translate into both (or either) compression or tension depending upon the unknown factors of heterogeneous crustal yield strength and varying lithospheric resistance to translational movement. Any compression from this source will tend to be maximized on the western side of landmasses; while tension, if any, would tend to appear on their eastern flanks.

In summary, compression generated as a result of rotational deceleration is a combination of factors: A) reduction in total surface area from increasing density B) changes in geometry from reduction in oblateness (circumference) —plus a number of possible lesser influences suggested by other authors in the past, though not critical to this discussion.

The dominance of generally N-S mountain building is understandable if we first consider an over -all field of compression. Upon this is superimposed added vectors of lesser force oriented E-W. The net result then is a dominance of E-W compressional force which can be relieved by faulting, folding and shortening to produce linear N-S orientation.

DIRECT MEASUREMENTS OF COMPRESSION

Among the more definitive studies that demonstrate the geographically widespread presence of compression and shear stress in the upper crust have been those reported by N. Hast (1958, 1960, 1964, 1967, 1969, 1973).

Engineering measurements of stress have been conducted by *Rock Stress Measurements AB*, *Laboratory* of Stockholm, Sweden at locations in Fennoscandia, Spitzbergen, Ireland, Portugal, Switzerland, British Columbia, Liberia, Zambia, Iceland and elsewhere. The technique involved making about 50 measurements per drill hole in cores of competent rock recovered from surface to depths of 1000 meters. Between 1958 to 1969, some 20,000 measurements of absolute stress were made.

Hast (1969) reported that measurements performed at several localities from Spitzbergen in the Norwegian Sea to Zambia in south Africa indicate that the horizontal stress field measured in Fennoscandia may belong to a 'general stress system according to which large parts of the Earth's crust are stressed.'

> "Horizontal compressive stresses in the bedrock were found at all points of measurement on Iceland, and in specific areas the same order of magnitude as in Fennoscandia.. Where the Mid- Atlantic Ridge is assumed to encounter Iceland, the orientation of the maximum horizontal shear in the Icelandic bedrock agrees with the orientation of the ridge that may have its origin in shear stresses in the crust."

> "In connection with the questions regarding the shrinking or swelling of the Earth it is significant to note that among all these recordings not a single one has pointed to a state of *tensile* stress; all have indicated horizontal compressive stresses in the crust, several times the magnitude of the stresses due to the weight of the overburden at the same level."

The most remarkable and important findings related to compression, and vertical shear stress, resulted from work in Iceland and on Europe's Mont Blanc massif. (Hast 1973).

Along the southeast coast of Iceland, holes drilled at two locations tested solid bedrock consisting of gabbro and granophyre. These crystalline rocks are commonly associated with origin in an environment of plutonism and not that of extrusive basalt predicted by plate tectonics 'spreading' set nearly astride of the mid-Atlantic ridge. Hast also reported that the Reykjanes Ridge (south of Iceland) is not a tensional ridge, but a ridge of shear.

> Hast concluded: "----- it would appear that the Atlantic floor functions as a rigid plate that transmits large horizontal compressive forces and shearing forces between the continents and the islands in the Atlantic."

Hast continued this thought in 1973:

> "In the Earth's crust there exist fractures in vertical planes of large horizontal extent formed by the presence of a high horizontal shear stress field. An example is the floor of the Atlantic

> Ocean where fracture zones appear in two directions at right angles to each other representing an orthogonal fracture system. Only a great world-wide horizontal shear stress field can produce such an effect."

Similar prominent, lengthy, E-W fracture zones exist in the eastern Pacific. These are exemplified by the Mendocino, Clarion, Clipperton, Galapagos, and others. These features too, are reported as near vertical faults. It is noteworthy that these extensive features, while traversing regions where eruptive volcanic peaks are scattered abundantly across the sea-floor, are typically devoid of volcanic activity. Such major ruptures of thin oceanic crust would seem to be potential conduits for liquid magma extrusion. One might speculate that high compressive stresses may preclude the opening of such avenues.

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Hast's report on work near the French-Italian border on a tunnel through the Mont Blanc massif may reveal a *profound discovery*.

Hast found initially that, studies in the Mont Blanc tunnel massif confirm the sole presence of horizontal compressive stress conjoined with *high vertical shear stress* and fracturing. These measurements were made from drill holes at sixteen measuring points along a 11.6 km road tunnel between Italy and France where the overlying rock ranges in thickness from a maximum of 2500 meters and a minimum of 1750 meters. The tunnel cuts through 7 km of gneiss-granite at the center, which is bounded on one side by crystaline schist and by limestone on the other.

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World-wide crustal compression is further supported by studies of crustal stresses in Australia.
In their abstract, Denham, Alexander, and Worotnicki (1979), state that, "evidence from earthquake focal mechanisms, *in situ* stress measurements, and surface deformations, indicate that the Australian continent is in a state of substantial horizontal compression."

They continue:

> "The results give principal stress orientations in different directions for different regions of the continent; it is therefore clear that simple models derived from plate tectonic concepts cannot be applied directly to explain the high observed stresses or their directions."

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Denham and his co-authors arrived at two main conclusions:

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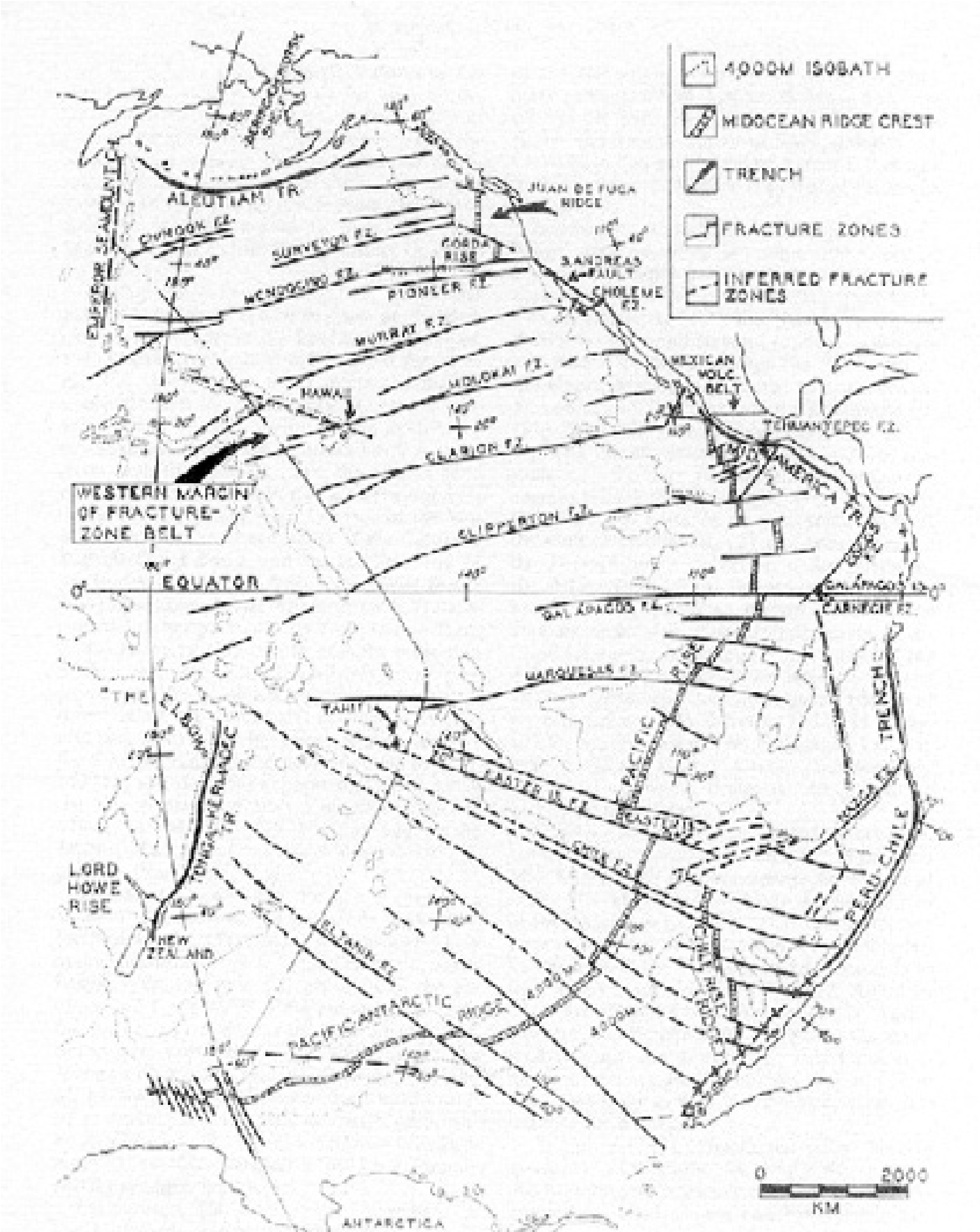
Anfiloff (1992) explains the mechanism of vertical movement largely by the emplacement of thermal melt bubbles beneath the ancient crust. The exact mechanism is rather nebulous as is the source of compression said to hold the continent together. Other investigators have tended to agree with this summation.

The present author will mention that the functions of both vertical crustal block motion and directionally non-exclusive horizontal compression are readily understandable within a framework of Earth's slowly increasing gravity and surface compression resulting from rotational deceleration, as discussed elsewhere

* * * *

Figure 10.3.1
Map showing major fracture zones, Pacific Basin. Note westward convergence into Tonga-Solomons - New Caledonia area. Sources used are Menard (1967) Herron & Hayes (1969) Hayes and Pitman, and Menard and Chase (1971). Taken from A. Meyerhoff (1972).



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*   *   *   *

FIGURE 7. Vertical planes of fracture in the east–west and north–south direction in the Mont Blanc massif; the top of Adolfo Ray (3670 m). The directions of the planes are the directions of horizontal τ_{max} and shear fractures found by the measurements at tunnel level.

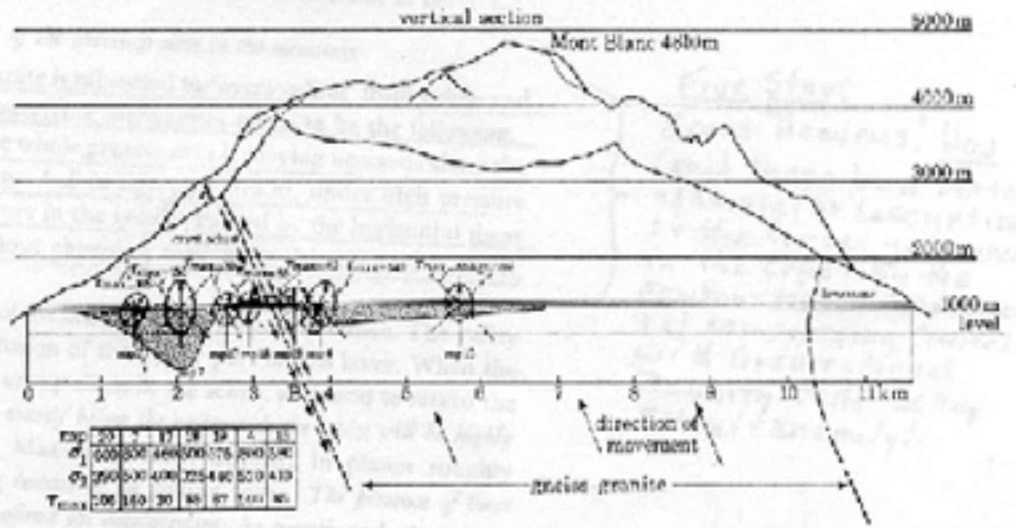


FIGURE 8. Vertical section through the Mont Blanc massif and the road tunnel. The ellipses demonstrate the stress distribution in the bedrock at tunnel level. The table in the figure shows the magnitudes of the stresses. High vertical shear stresses especially in the schist corner. The shaded (overpressure) and stippled (underpressure) areas show the difference between the measured vertical load and the dead weight of overlying rock calculated from the height of the mountain at the points of measurement.

Figs. 11.1.1 & 11.1.2 (figs. 7&8, above, taken from Hast, 1973)

11.3 PHOTOGRAPHS OF MOUNTAIN FRACTURE PLANES

The following photographs display characteristics that bear features remarkably like those described by Hast (1973) as found in his work on a tunnel in the Mont Blanc Massif.

Hast described vertical fracture planes oriented E-W and N-S (at 90 degrees) and extending upward through overlying granite a minimum of 1760 m to a maximum of 2500 m where the fractures are exposed above as vertical rock faces on Adolfo Ray peak. (Figure 11.1.1)

Hast ascribed these vertical fracture planes to the presence of high horizontal compressive stress “conjoined” with high vertical shear stress at very deep levels within the earth. This, he believed was the result of “overloading from below” and was thought to be “common especially on continental blocks.”

This suggestion if true, strongly supports the author’s concept of gravitation density cells as an active process in the upper levels of Earth’s crust.

The following photos were selected by the author to illustrate features that can <u>not</u> have been created by processes of erosion, but are apparently due to internal stresses within the crust and gravitationally controlled uplift. .

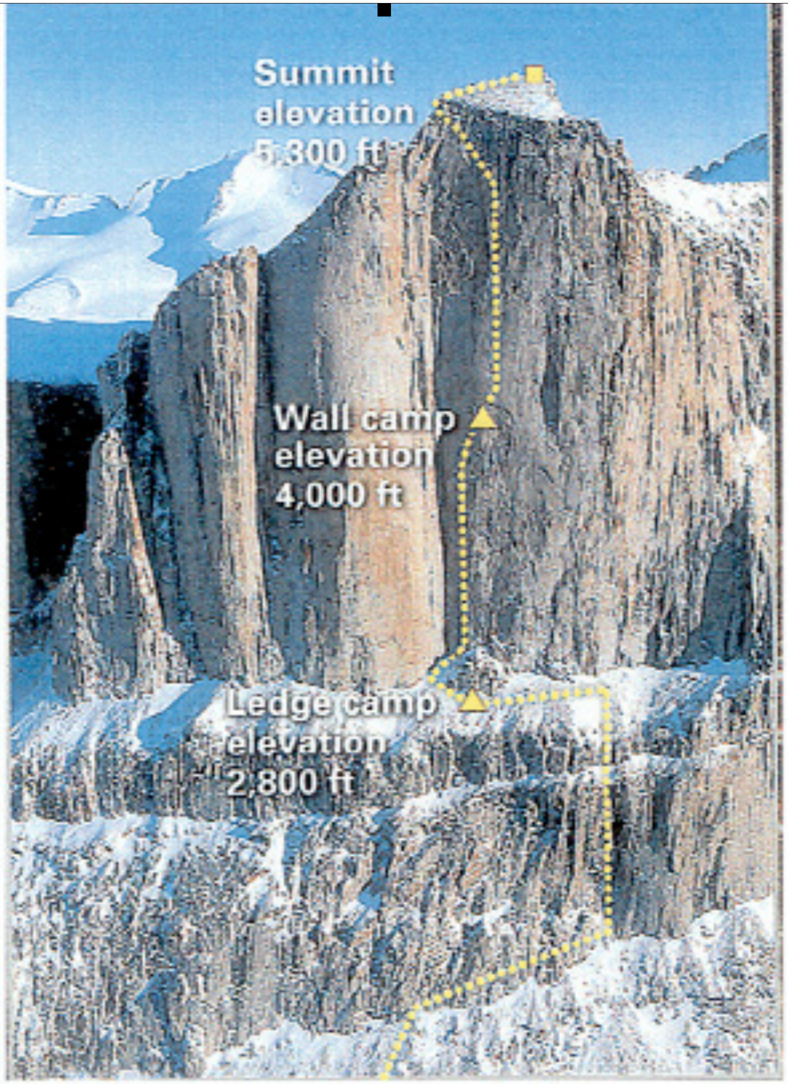
* * *

Figure 11.3.1

GRANITIC PEAKS OF THE NORTH PALISADE, SIERRA NEVADA, CALIF.

Photo by: Ron Redfern in “The Making of a Continent” (1983)
Times Books, N.Y.

Figure 11.3.2 GRANITE SPIRES OF CERRO TORRE MASSF IN PATAGONIA, ARGENTINA
CERRO TORRE ON RIGHT 10,177 FT. (3102M) PHOTOS BY THOMAS ULRICH
PUBL. NAT. GEOGRAPHIC MAR 2000



GREAT SAIL PEAK, BAFFIN ISLAND, CANADA

PHOTOS BY GORDON W. WILTSIE. PUBL. NAT. GEOGRAPHIC JAN 1999

Figure 11.3.3

GREAT SAIL PEAK, BAFFIN ISLAND, CANADA

PHOTOS BY GORDON W. WILTSIE. PUB. NAT. GEOGRAPHIC JAN 1999

Figure 11.3.4

11.4 ARCHAEAN CRUSTAL FORCES

Deformation in the Archaean and Proterozoic

In *Evolution of the Earth's Crust*, a compendium edited by D.H. Tarling (1978), Bridgewater et. al.(1978) discuss the Archaean crust complexes of the north Atlantic consisting of gneisses, schists and other medium to high grade metamorphic terranes ranging in age from 3600 to 2500 million years BP. These crop out in Labrador, Greenland, Scotland, and the Baltic Shield.

Rocks in these regions dominantly display high strain, extreme attenuation and a lack of old depositional contacts suggesting that original layered sequences have been disrupted and sometimes repeated by thrusting and possible nappe formation.

Sutton (1978) discusses the Proterozoic areas of these same north Atlantic terranes.

> "The early Proterozoic igneous activity was everywhere linked closely with crustal deformation which was especially marked by long narrow belts of high strain. The result was to produce a heterogeneous crust in which intensely deformed rocks, often in steeply inclined zones, alternated with blocks which had largely escaped early Proterozoic deformation and igneous activity. This on a much less extensive scale than at the height of the great late Archaean event some 200 m.y. earlier."

Late Archaean and early Proterozoic times marked a stage in early Earth history when intra- continental deformation and igneous activity was more extensive than in recent times. Another period of apparently intense crustal mobility, deformation, and volcanic invasion occurred during a period 1900-1600 m.y. ago.

Sutton describes rocks of Archaean and Proterozoic age comprising portions of the shield exposed for 600 Km along the southerly west coast of Greenland and extensively along the east coast of Labrador in the following manner:

> "The grade of metamorphism is high practically everywhere. Gneiss predominates and the whole represents a deep section through the crust. Folding was complex with early isoclinal folds refolded repeatedly during Archean times."

> "Older refolded structures alternate with strongly linear straight belts, some of which are 100 Km in length. The belts of high strain can have sharp boundaries, are unusually steep, and in view of their length, the longest probably continue downwards through the crust into the mantle."

These observations and those of Bridgewater (below) appear to be in concert with those of Hast

(1973). Hast found a strong correlation between high compressional stress and high vertical shear stress, wherein the latter leads to large vertical fractures extending to deep levels within the crust.

The western boundary of the Archaean pre-Ketilidian in Labrador is regarded as thrust (Bridgewater, et. al., 1975) while the northern and southern boundaries exposed in Greenland show evidence of large scale, ductile, shear movements on steeply inclined planes (Escher et. al. 1976).

Similarly, in studies of the Barberton Mountain formation complex (>3000 m.y.) In S. Africa
Anhaeusser (1971) describes metamorphosed rocks of ultramafic, volcanic, sedimentary and intrusive origin which were subjected to intense folding, shearing and regional deformation. While he postulates a rather complex series of events including gravitationally induced vertical deformation, all of the final results speak strongly of compression as a dominant factor.

These kinds of tectonic features reflect well what one would expect in the earlier phases of Earth history imposed by an environment of more rapid Earth rotation, a closer Moon creating stronger body tides, and a greater rate of rotational deceleration. All of this would invoke more rapid and more intense changes in Earth-crustal dynamics.

Compression due to increasing gravity and consequent surface area reduction is reflected in repeated events of Archaean-Proterozoic folding, the lineation in gneisses from their mobility, and in large scale shear movements. The long, strongly linear, belts oriented in near vertical aspect may result from differential epirogenic uplift between adjacent crustal blocks combined with compressional shearing.

The over-all state of dynamic forces in the crust during these periods could perhaps be described as a *Dynamic Melange*, wherein conflicting forces existed almost simultaneously considering the crustal surface as a whole and the chronology we are dealing with. This would include horizontal and vertical tensional stress generated by lunar gravity torsion and epirogenic adjustments, both positive and negative, as well as the dominant compressional forces resulting from two surface reduction mechanisms, and lunar gravity vectors tending to shift disparate crustal plates. These are discussed in more detail in chapter ______.

12.0 EPEIROGENESIS

Epeirogenesis is a concept of crustal movement introduced by G. K. Gilbert in 1890, and later defined by H.Stille (1918) who believed the characteristic feature of Epeirogenesis was slow vertical movement up or down--- with no alteration of the crust.

Beloussov (1962, p195) criticizes the terminology stating that epeirogenesis literally means continent making. But, he said, vertical movements are both upward and downward and in the latter case may destroy continents and form seas in their stead.

Beloussov rejected the terms orogenesis and epeirogeny as absurd misnomers, since in his view neither continents nor mountains are generated by these movements. He seemed to be hung up on a concept of crustal "oscillation." Beloussov describes various oscillations of measurable vertical movements in the framework of human history; also those evident from older geologic features such as shoreline and valley terraces, ancient sub-sea river channels, and submerged platforms dated in Quaternary or late Tertiary.

Many of the latter geologic features are found along coastal zones where the uplift or subsidence of land is difficult to distinguish from sea level changes or isostatic adjustment related to glaciation. He also describes oscillation in past geologic periods, based on stratigraphy, but, the fundamental forces causing these irregular movements are left unexplained. In any case, it is not an accurate description of world-wide tectonism.

Epi-continental movements and epi-oceanic crustal movements are, over extended periods of time, essentially uni-directional: continents elevate, and ocean basins sink. Although over short periods of time, for a variety of reasons there may be localized reversals of up or down movements which can give the appearance of oscillations. These, the author believes, are subsidiary isostatic adjustments, correlated with crustal heterogeneity, or symptoms coincident with "main feature "tectonic processes that control the big show.

In his analysis of tectonism and its effects on the Earth's crust, Beloussov (op.cit.) extensively, and in great detail, examined clues to tectonic movements revealed in the stratigraphy of sedimentary deposits in widely separated areas of the world. Much of his work describes the features of basins in Europe, the Mediterranean and western Russia. The work is classic and displays remarkable analytic insight.

His interpretations and conclusions turn largely on the concepts of crustal oscillations, cycles, and waves of crustal motion. This is not surprising, nor is it to be seriously criticized as sedimentary beds in stratigraphic sequences throughout the world often display repetitious cyclical features suggesting the application of a generalized interpretation.

Beloussov, however, was disadvantaged by lack of a mechanism to explain the "oscillations" he saw as producing uplift and erosion, paired with subsidence and deposition. These factors, in turn, controlled the thickness of beds, types of sediments and their distribution. Repeated cyclical sequences he attributed to crustal oscillations of varying amplitude elevating or depressing the land to cause regressions and transgressions of the seas. He left to speculation and future research why the crust suffered these numerous oscillations.

The present author rejects the term “oscillations” as being misleading. The term implies that some undetermined force or mechanism causes the surface of the crust to elevate and subside in repeated cycles, long and short, at various times and locations. Emphasis is on the elevation and subsidence of land surfaces somehow related to heterogeneity in the crust. The role of change in sea level in this scenario is generally ignored.

The hypotheses set forth in this volume easily supplies the forces that maintain the Earth’s crust in a state of murmuring instability-----elevating, depressing, compressing, crushing, folding, altering climates, and expelling molten materials throughout Earth history. The ultimate cause of this instability, once recognized, is easy to understand, yet, in altering the Earth’s surface and molding geologic history, the actual suite of active forces and the subsidiary mechanisms at play is far more complex than any hypothesis yet proposed.

The oscillations suggested by Beloussov mislead (and fail) for one basic reason: Vertical movements of land cannot always be reliably separated or distinguished from changes in eustatic sea level. The sedimentary sequences from which cycles of subsidence, uplift, erosion, and deposition are interpreted are solely a function of the relative levels of the sea and land. The controlling baseline is sea level above which erosion may occur and below which sedimentation may take place. The sinking or elevation of land relative to the sea, or the rise or drop in sea level relative to land have identical effects on the processes of erosion and sedimentation.

Note that a slow reduction in Earth’s surface area (assuming a fixed volume of ocean water) can cause a eustatic rise in sea-level as the available size or volume of the world’s ocean basins
(absent deepening) is diminished. Shallow epeiric seas can flood low areas of continents and increase the water depth on marginal shelves. Under these conditions increased depth of epi-continental waters can occur independently of ocean basin subsidence, though some oceanic subsidence might be expected to accompany the process of Earth surface reduction concordant with increasing gravity.

The world-wide effects of Earth’s dynamic deceleration described in sections 8.0 thru 14.0 cause changes in eustatic sea level by altering ocean basins in size and depth to raise and lower sea levels world-wide (see below). Similar forces elevate continents epeirically or cause areal depressions and elevations due to crustal strength and density factors.

At the same time, compression may be engaged in folding, faulting, creating elevated welts, or troughs of depression. It should be recognized that generally all of these processes are, or can be, active simultaneously in any given region of the crustal surface. Of course, isostatic adjustments will be at work in all cases. Thus, after all factors are taken into account, we may not always be able to tell from stratigraphic features alone whether depositional changes resulted from oscillation of the crust or eustatic changes in sea level.

The term “cycle” should also be used cautiously and for restricted applications. The term inherently implies past or future repetition caused by mechanisms which may or may not be repeated. Earth history, for example, is controlled by factors generated in a system of decaying rotational dynamics. Thus, a specific physical tectonic “cycle” may never be repeated.

There is evidence suggesting that oceanic areas underlain by continental sedimentary rocks --- Lower Paleozoic and possibly older— have subsided and are now part of the oceanic crust in the Northwest Pacific (Choi, D. R.1987) (section 19.6) and in the Northeast Atlantic. * * * *

13.0 GRAVITY AND EPEIROGENY

Belussov (1962) explained in his classic text book (pp 59-60) how relatively light materials in the crust superimposed on the heavier and more dense materials in the fluid or viscous mantle maintain isostatic equilibrium when oceanic and continental crust stand at markedly different relative elevations.

Taking average densities for the heterogeneous continental crust (2.7) and the more dense (3.3) upper mantle surface, he clearly explains how the thicker, less dense, continental crust maintains, over time, isostatic equilibrium by displacing the denser mantle materials and forcing them deeper. In this manner, continents can stand higher and ocean basins can stand much lower with both being in isostatic balance. (based on the existing gravity—this author's words) Beloussov put it this way:

> Since, to the first approximation, the mass of the earth's crust beneath any point on its surface is the same as beneath any other point, the crust is, in general in a state of equilibrium. Such an equilibrium would have to be established, according to Archimedes' law, if the earth's crust were floating on a denser but still viscous substratum. Let us imagine a nonhomogeneous crust floating on the surface of a substratum that is denser but fluid enough that the crust may sink into it, in conformity with Archimedes' law. This law states that a floating body displaces an amount of the substance in which it is floating equal to its own weight. Therefore, more of the (3.3) substratum is displaced under the heavier parts of the crust than under the lighter, and the former sink to a greater depth than the latter.

Under these conditions, and in view of what is to follow, this author will state the foregoing in slightly different words.

Beneath areas of thick continental crust (2.7 density), denser material of liquid or plastic mantle (3.3 to 3.6) is depressed below "normal" for pressures at that depth because of the superincumbent weight of the thick continental plate. Beneath ocean basins the *top* of this same dense mantle stands higher, or above "normal."

Although the mantle here is bearing the weight an oceanic crust of greater density (3.0-3.1), oceanic crust is much thinner than continental crust (2.7). The surface elevation of the ocean basin crust will however, be standing far below the surface elevation of continental crust.

So what we have then, is a thick, light, continental block standing (floating?) on dense underlying mantle. In juxtaposition to this we have a thin oceanic crust (intermediate in density), laying on the same dense mantle material. At some point of depth in the mantle the combination of thicknesses and densities, under prevailing conditions of gravity, will result in vertical weight columns beneath the continental and oceanic crusts that yield equal pressures at equal depths. The two crustal areas will then stand in isostatic equilibrium. (Figure 13.0.1)

These conditions have been well understood for years and covered by many authors. The principle of isostacy is widely accepted almost to the point of its being a "law."

Two points to note here are of paramount importance:
First, is that beneath ocean basins the top of the relatively dense (plastic-viscous-fluid?) mantle, even at oceanic depths, stands well above its equivalent beneath the continental areas. This has long been recognized.

Second, *net gravity* is the key player in this scenario. As discussed by the author, net gravity slowly increases as earth rotation decelerates. Beloussov and other investigators dealing with isostatic equilibrium did not divine the importance of this on-going process (dare we say fact) in every aspect of tectogenesis.

Consider conditions as outlined in the above discussion. Assume the correctness of slowly increasing gravity and the effect it would have on the depth of our hypothetical ocean basin and the elevation of its continental partner.

It is critical to examine the relative *weights* of the materials in this scenario. Remembering from physics that: weight equals mass times the acceleration of gravity, we simplify to:

wt. = mg

Now compare the weight change effected by a gravity increase on mantle @ 3.3 density vs. continental crust @ 2.7density. Use as acceleration values g = 978 cm/sec/sec and 983.2 cm/sec/sec. These are actual present values at the equator and poles. Therefore, to assume such a modest increase at the equator due to rotational deceleration from past conditions is very realistic. The figures below are for volumes of one cubic meter.

When gravity acceleration increases from 978.0 to 983.2 cm/sec/sec ---
a) the increase of wt. in 1 cu. meter of continental crust @ (2.7 dens.) = 32 Lb.
b) the increase of wt. in 1 cu. meter of mantle material @ (3.3 dens.) = 39 Lb.

Therefore, the increase in wt. of mantle vs. continental crust = (39-32) = 7 Lb./cu meter

It is readily seen that as the value of *net gravity* increases, the weight of a material of density 3.3 will increase faster than that of 2.7 density material. If we return to the situation above, we find that in the initial equilibrium condition outlined (i.e. oceanic crust vs. the continental crust), the oceanic crust plus the 3.3 mantle below it---- has less vertical column above the depth of equal pressure beneath both blocks, but more of the column is of 3.3 density. Therefore, under conditions of increasing gravity, the oceanic column will gain weight faster than the taller continental column consisting of 2.7 density, plus a thinner interval of 3.3 mantle, below the continental crust.

This increased weight means that the pressure at the original depth of equilibrium pressure (isostatic conditions) increases faster under the oceanic block than it does under the continental block. Equilibrium is upset and mantle material of 3.3 density and greater will flow from beneath the oceanic block to a location under the continental block (Figure13.0.1)

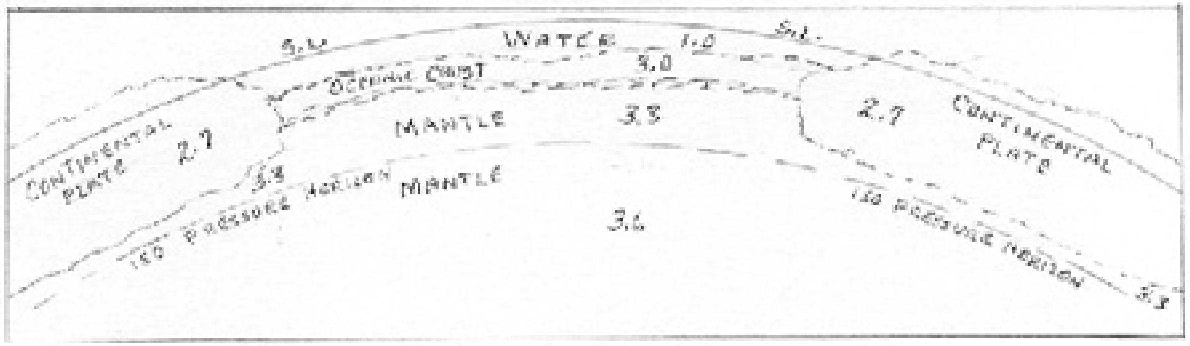


Figure 13.0.1: Illustrates the relationships between continental plates (2.7 dens.), Oceanic Crust (3.0 dens.), and mantle (3.3 dens.). Increasing net gravity has different effects on the weight of each entity resulting in isostatic adjustment (epeirogeny).

The mantle under the ocean basin thus affected, along with the oceanic crust upon it, will sink epeirogenically, while the flow transfer of mobile mantle to lower pressured space below the continental crust will force the continental block to rise. These movements will be controlled by isostatic considerations in accordance with local density variations in the heterogeneous crust.

Looking Backward

The recognition of changing *net* gravity as a fundamental component of tectonic processes opens a wide vista for research into a better understanding of Earth's geologic history and the potential to find answers to many problems that yet evade us. New answers will, of course, pose new questions. It is endless.

The scenario of epeirogenic movement induced by gravity change as outlined above immediately suggests further speculations. Among these are consideration of the effects of reduced net gravity in the Archaeozoic, Proterozoic, Paleozoic and Mesozoic.

Looking backward at reduced values of gravity--- we may ask, would 'playing back a tape' in time reveal a reversed sequence of vertical movements indicated above? If so, were ocean basins shallower but more widespread in the past? Did continental areas frequently stand lower, and, were inundated by epicontinental seas. Have thick sedimentary sequences on continental platforms since been stripped by erosion? How were climates, ocean currents, and local weather patterns affected?

Did these possible changes cause major extinctions of life? What about glaciation? Are thick sequences of ancient sediments buried beneath a pavement of repeated volcanic eruptions in parts of today's ocean basins?

* * *

(Draft note 10-10-00)

Revised 11-18-2002

“ 9-07-03

13.1 Isostacy

While the evidence for large scale continental isostacy is overwhelming, less grandiose vertical adjustments to surface crustal weight shifts may involve a more simple mechanism.

Isostacy in its major concepts, according to both the Pratt and Airy models involves vertical movement of thick crustal blocks over long periods of time. It is supposed that the adjustment resulting from the addition or subtraction of large masses of material by erosion, sedimentation and glaciation over broad areas will provoke vertical adjustment from the surface down to a crustal depth where some sort of plastic flowage laterally will permit the appropriate movement over an extended period. This seems reasonable based on physical principles and has been long established in the literature.

One may inquire, however, whether additional mechanisms are involved at shallower depths, or where vertical movements of a few meters or tens of meters result from surface loading or unloading over a more restricted area.

Examples that come to mind are:
a) Rebound over formerly glaciated areas in Fenno-Scandia
b) Rebound in the area formerly occupied by Utah’s Pleistocene Lake Bonneville.
c) The occurrence of small quakes attributed to the filling of reservoirs behind newly constructed dams.

The Fenno-Scandia rebound in formerly glaciated areas and the former Lake Bonneville, now greatly reduced, have both been described as examples of isostatic adjustment. Are they isostatic in the sense of Pratt and Airy? Perhaps not. It seems unlikely that ice sheets of probably less than 5000 feet of thickness, or, a few hundred feet of lake water spread over a relatively small region would involve physical movement to crustal depths of up to 80 or100 Km.

All materials are compressible to some degree under pressure, even water and steel. Consider also, that all rocks have some degree of porosity, however small. Near surface rocks may also be jointed and fractured. The fact that sound waves and the P&S waves of earthquakes travel through the lithosphere proves that rocks have compressibility and elasticity.

This being the case , it seems reasonable to speculate that surface loading by glaciation and lake waters will, over time, cause the rocks below to be depressed through compression and elastic adjustment to downward pressure. The transmission of these effects will be confined at most to a few Km but not to depths of 60 to 100 Km as demanded by the Pratt or Airy models of conventional isostatic theory. At some level of loading and areal extent such as extensive continental glaciation, Pratt and Airy type adjustments as well as surficial compressional effects would both be expected.

In the unloading phases of examples like Fenno-Scandia and Lake Bonneville, the rebound over several thousand years has been called "isostatic." Perhaps this is a misnomer and some other designation should be applied.

Isostacy was first named by Clarence Dutton, based largely on prior work by G.B. Airy and J.H. Pratt in the 1850s. Their models were somewhat different, but in either case, their concepts rationalized that at some unknown depth the weight of the overlying rocks would everywhere be the same—hence isostatic.

Consider, however, the case where a continental block of light density is in juxtaposition with an oceanic block of greater density. Assume they are in isostatic equilibrium at the existing value of gravity. When an increasing value of gravity reaches a certain point, the two blocks will not be in equilibrium. An increase in Net (g) will make the weight of both blocks heavier, but the more dense oceanic block will be heaviest causing it to sink. Increasing pressure below it will cause plastic mantle to be displaced laterally to a location beneath the continental block where the pressure is relatively less. The continental block will elevate slightly or remain in approximately the same position even though the latter's weight has also increased... In either event, isostatic equilibrium will again be achieved.

13.2 Isostacy and Mountain Building

Beloussov (1962 p 60) listed among 'Basic Problems in Tectonics' the following:

> "The greatest (isostatic) anomalies have been observed in zones of the most intensive tectonic movement. ----To attain (isostatic) equilibrium the Caucuses would have to subside; instead of this, they are rising."
>
> "Many similar cases provide convincing evidence that isostatic forces ----- the tendency to restore isostatic equilibrium— cannot be considered the cause of tectonic movements of the Earth's crust. Tectonic movements, on the contrary, destroy the equilibrium."

Beloussov was correct, of course, and recognized that some other mechanism(s) must cause tectonic movement, but he then went on to point out that Y. N. Lyustikh and V.A. Magnitskiy have shown that slow vertical movements on platforms that result in "the formation of anteclises and syneclises are accompanied by horizontal displacements of the material in the depths— moving outward from beneath a syneclise and inward beneath an anteclise."

The latter thoughts are interesting but probably not accurate regarding depth of material movement and there was no suggestion of an alternative mechanism. It appears that neither Beloussov, nor Lyustikh and Magnitskiy, knew the role that gravity, and particularly variation in gravity, plays at this stage. One could say, "They were close , but, they get no cigars."

13.2a <u>Vertical Uplift at Angel Falls, Venezuela</u>

In Venezuela, S.A. there is a broad jungle covered plateau made famous by “Angel Falls” —highest falls in the world. One edge of the plateau is limited by a vertical scarp over which a river plunges in free-fall for about 3000 feet. Daredevils jump or ride bicycles over this vertical precipice to drop more than 2000 feet before opening a parachute to land safely below.

One may inquire how such a geologic declivity could have been created. There is little in plate tectonic hypothesis to explain the vertical up-lift demonstrated here or in other high plateaus in the extensive Guiana Highlands nearby. Certainly such a declivity was not caused by erosion.

A more reasonable explanation might be that uplift (along a fault) resulted from regional isostatic adjustment related to the concept of a gravitation density mechanism.

* *

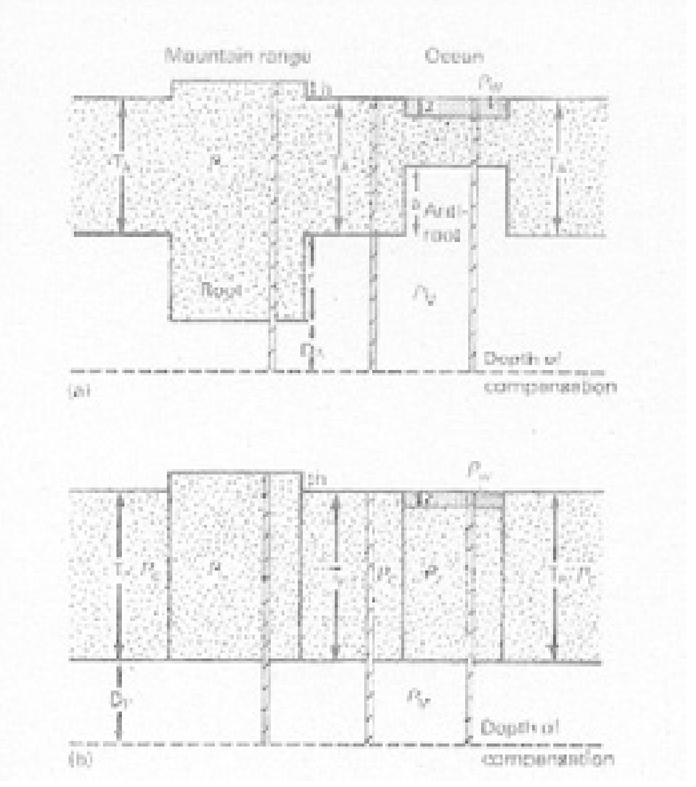


Figure 13.1.1

(a) **Airy** mechanism of isostatic compensation. h, height of mountain above sea level; z depth of water of density Pw; T, normal thickness of crust of density p, : r, thickness of root; a, thickness of anti-root; Da, depth of compensation below root: Pm density of mantle.

(b) The **Pratt** mechanism of isostatic compensation. Legend as for (a) Except Tp, normal thickness of crust; Ph, density of crust beneath mountain; pz, density of crust beneath ocean; Dp, depth of depth of compensation below Tp.

13.3 Tidal Effects on Crustal Plates of Different Density

Consider conditions where continental crust with average density of 2.7 g/cc lies adjacent to and in contact with oceanic crust having an average density of 3.1 g/cc. Assume the continental block is about 100 Km thick; the oceanic block about 35 km thick, and that their zone of contact is two thousand kilometers in length. This essentially describes our current understanding of the physical relationships existing along large segments of the Pacific rim especially in regions where deep trenches occur; e.g. the Chilean, Mid America, Aleutian, Kuril, Japan trenches and others.

Consider how tidal forces affect these two contiguous blocks twice daily. The zone or “seam of contact” between these two physically distinct crustal entities is subjected to the external influence of lunar and solar gravity. The maximum force occurs at a high tide period facing the moon. A lesser force occurs at “lower high tide” facing 180 degrees away from the moon on the opposite side. Between these two tidal maxima, the tidal forces relax during periods of “low tide.” Thus, the two plates of different densities are twice daily subjected to forces which tend to move them vertically.

The principle of isostasy has been studied and discussed in the literature for decades to the point where it is now generally accepted as fact. Proceeding from this, it follows that two discrete blocks standing at different surface elevations, but in essentially average isostatic equilibrium at some deeper basal elevation, will have different densities. A continental crustal block will be less dense and have less mass per unit volume than an adjacent oceanic block of the same size and thickness.

If each of these blocks is subjected to daily variation in the effective force of lunar, solar, and earth gravity (attraction and relaxation) the oceanic block and mantle, because of greater density will be subject to a greater vertical force (up and down) than the crustal block. The latter, at equivalent equilibrium depths will have less density and mass. Therefore, even though both blocks are subjected to the same timing and gravitational fields, the range of forces acting to produce motion, higher and lower, will not be equal.

Let us now inject another factor, that of horizontal compression. Whether one subscribes to the subduction hypothesis or some other tectonic mechanism, it is evident that compression is a factor effective at a relatively shallow depth where the two dissimilar blocks are in contact. It is also evident that this zone or seam of contact, often contiguous with a trench, is also a zone generating both tectonic and thermal activity dominantly along the margin of the continental block.

A major portion of this mechanical and thermal activity occurs at moderate depths of less than about 100 Km along the Wadati-Benioff zone. Benioff (1954) and others found, that based on plotted epicenters, this zone dips landward at approximately 22 to 25 degrees above a depth of about 100 Km., increasing rather abruptly to dip at 60 degrees below that depth. This geometry places any frictional heat generated landward of the surface expression of contact.

An inspection of the distribution of volcanoes, both currently active and those active in Holocene and Recent times reveals a singularly consistent pattern. Around the Pacific Rim where deep trenches occur proximate to continental margins and island arcs, there is generally a series or chain of volcanoes set back from the trench on the landward or island arc block. In gross aspect they are rather closely and uniformly spaced and all have roughly the same step-back distance from the trench or seam of oceanic-continental contact.

If found at only one or two localities, the relationship could be ascribed to serendipity. However, this pattern of volcanic activity appears related to trenches around the entire Pacific Rim. The possibility that the birth of these volcanoes is directly related to the process active in creating the trenches is hard to dismiss. (Figs. 13.3.1, 13.3.2, 19.3.1)

In any event, a test of the validity of differential vertical movement from body tides between continental and oceanic blocks would seem feasible using modern technology. Tide gages dependent on sensors sensitive to water pressure as a measure of depth could be placed on the ocean floor seaward of a trench at 10-12000 feet of depth. A series of these recording gages would then be compared with standard tide recorders placed in suitable locations along the coast nearby.

Another test of this concept could be made by examining the frequency and intensity of micro-seisms near trenches and seams of contact. Micro-seism activity should increase during rise and fall of the local tidal cycle and be at a minimum at tidal highs and lows. This would reflect mechanical crushing and faulting related to differential vertical movement under compressional stress.

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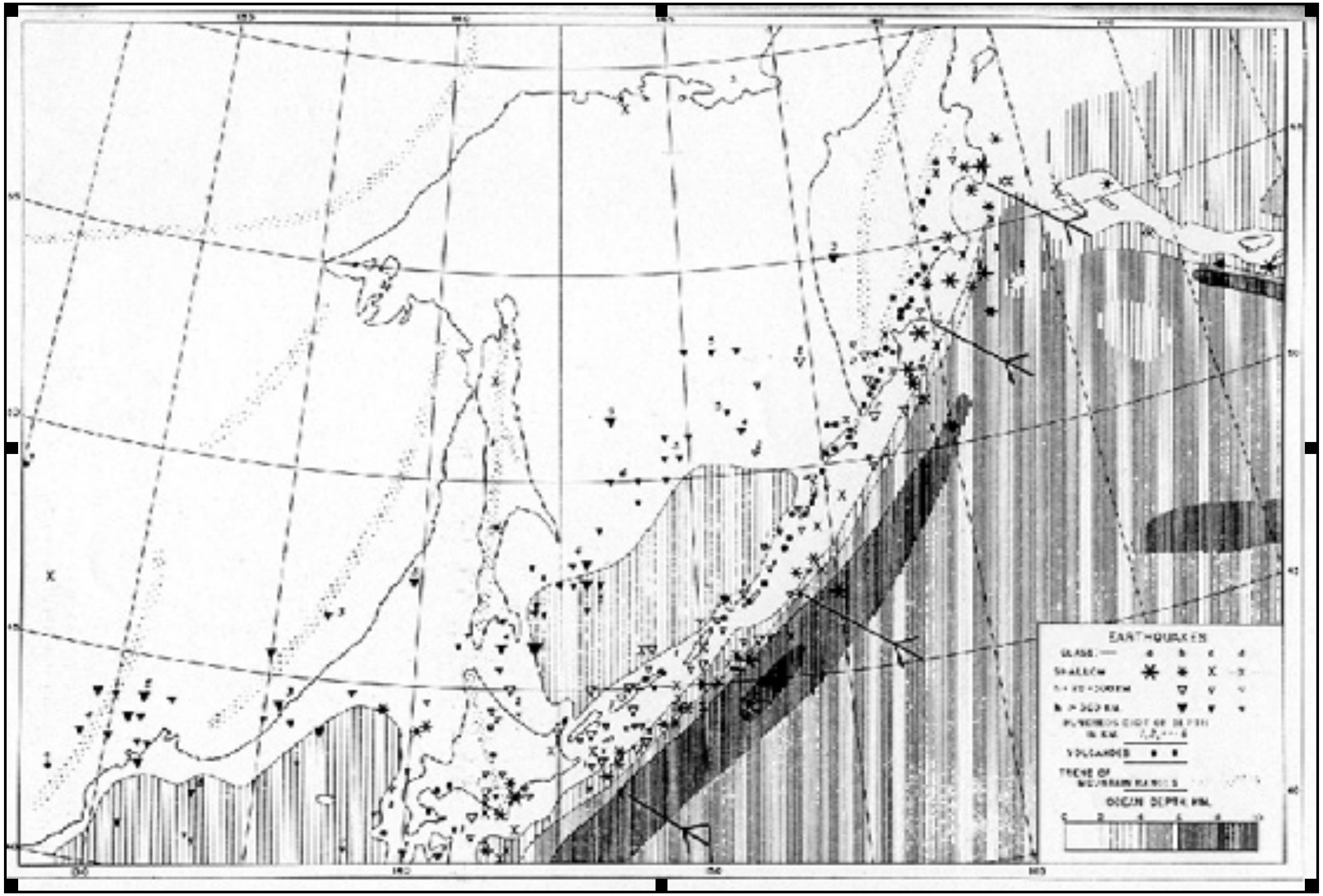
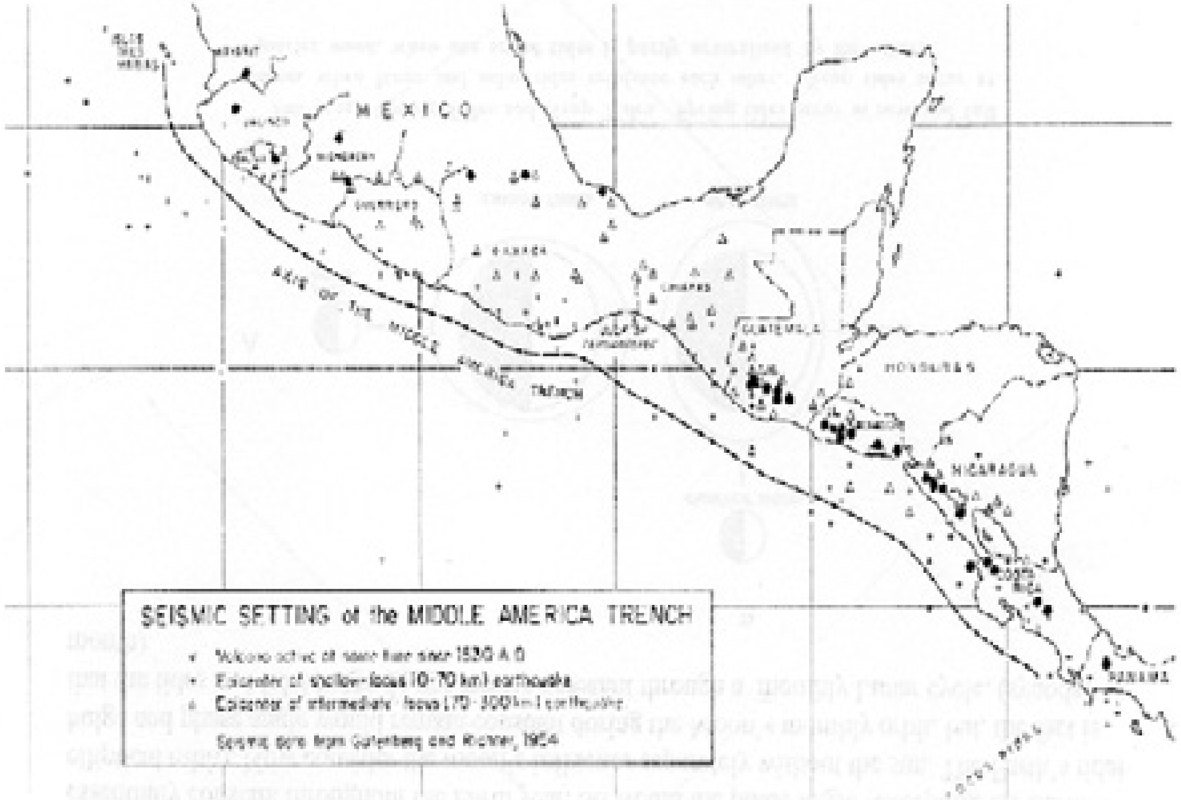


Figure 13.3.2

Location of volcanos and earthquake hypo-centers along the Kamchatka-Kurile Island plate and trench, northwest Pacific. Arrows indicate direction of relative motion of the Pacific plate. (From Gutenberg and Richter, 1954)



<u>Figure 13.3.1</u>

Shows location of volcanos active since 1530 A D and epicenters of earthquakes. From Gutenberg and Richter, 1954.

14.0 SUBSIDENCE OF OCEAN BASINS 9-25-2002

Rev.11-12-2002

Rev 6-10-03

14.1 Major Sinkings of the Ocean Floors

The instability of sea-floors and their tendency over long periods to subside is well recognized. This concept, first noted by Darwin's observation of atolls in the southwest pacific in 1895 is well proved in recent years by physical oceanographic surveys.

Data demonstrating this phenomenon has accumulated over the past four decades to the point where examination of recorded observations demonstrating the magnitude and ubiquity of this sinking demands an explanation of the cause and its role in geotectonism.

14.2 Pacific Basin

The earliest unequivocal evidence of sea-floor sinking came from submerged flat-topped volcanic peaks (guyots) in the Western Pacific. These are conical volcanoes grown from the deep sea-floor whose peaks once stood above sea level long enough to be truncated by wave action before sinking.

Repeated surveys using echo sounding depth recorders have mapped dozens of drowned guyots measuring their present tops at depths ranging between about 1000 to 2000 meters. Additional proof that atolls are of the same genesis, but, which have managed to maintain upward growth of fringing coral reefs at a rate equal to subsidence, has been demonstrated by drilling. Ladd and Schlanger, (1960) proved this on Eniwetok Atoll where, after drilling through coral debris from the surface, basalt was penetrated at 4222 feet (1287m).

The drowning of these volcanic sea-mounts is generally agreed to have begun in Late Albian to Lower Cenomanian (mid-Cretaceous) and may have continued to present day. What is important is the ubiquity and magnitude of this sea-floor subsidence demonstrated not only by these guyots but by evidence of other major subsidences scattered throughout the Pacific Basin.

Published information on guyots and other topographic features exposed to a sea-level environment in the past, but now submerged, is extensive: Hess (1946), Hamilton, (1956, 1957),
Ladd and Tracey (1957), Gibson (1960), Menard (1964), Resanov, I. (1978), Smith, D. (1985), VanWaasberg (1993) and others. The detail, distribution, and documentation of evidence of major subsidences commencing in the Cretaceous must catalogue only a small part of the true picture of exceptional instability in the Pacific Basin sea-floor, including, no doubt, some localized, temporary uplifts.

In a paper on *Major Sinkings of the Ocean Floor*, Resanov (1978) cites data acquired by the Deep Sea Drilling Program (DSDP) on sea-floor sinkings over 'enormous areas' in all the world's oceans. Drill sites were widely located in the Pacific, Atlantic and Indian Oceans. Most of the subsidence discovered is assigned to the Tertiary, but, in places it began in the Mid and Lower Cretaceous.
Resanov, p.511 concludes:

"Thus, for all the oceans of the planet (except for the Northern Ocean which has still not been studied from this aspect), major sinkings of the floor, measurable in kilometers, have been identified. These embrace at least half of the water area they now occupy. This geological phenomenon is so huge that it has no equivalent on the continents. In part, we may trace the sinkings since the second half of the Cretaceous Epoch. There is no doubt that this process occurs in Cenozoic time."

The forgoing is only a partial statement of subsidence in the Pacific basin. In addition, results obtained from the Deep Sea Drilling Project (DSDP) reported for the Pacific Basin by Resanov. (1978) include the following:

PACIFIC BASIN-TABLE I.

Location	Subsidence Amount	Time of formation or Sinking
Western Pacific Basins		
South Fijian Basin	5000 meters	Pliocene-Quaternary
Philippine Sea Basin	circa 5500 meters	Eocene (60Ma to 40 Ma)
Seas of Japan and Okhotsk	formerly land areas	circa M. Tertiary
NW Pacific & E of Mariana grp	1500-2000m	Late Early Cret.
Central Pacific		
Manihika Submarine plateau	3000 m	
Tuamotu Rise	3000 m	
Line Isl. Submarine Ridge	5000 m	
South of Hawaiian Isl group	2500 m	
Imperator Ridge	1500 m	

PACIFIC BASIN-TABLE II

Location	Subsidence Depth Range	Reference
Northwestern Pacific Guyots	950 - 2000 meters	Hamilton, E (1956)
Drowned Mts of the mid-Pacific	"Hundreds of fathoms"	"
Gulf of Alaska Guyots (ten)	550-2190 meters	Gibson, W. M. (1960)
Mendocino submarine ridge	1300-1400 meters	Menard, H. (1964)
Hawaiian submerged shelf	500 meters	"
Calif. Guyots (Erben & Fieberling)	410 -440 meters	"
Peru, Nazca Ridge guyots	400 meters (minimum)	"

Viewed in totality the argument for region-wide subsidence of the Pacific sea-floor is overwhelming. With this introduction we will turn to The Atlantic and Indian Ocean basins. Both of which have similar histories of major subsidence.

14.3 The North Atlantic Basin

terrestrial conditions, or shallow water deposition in the mid to late Cretaceous over a large part of the north Atlantic. These areas subsequently foundered. Probable Proterozoic metamorphics, Paleozoic and Mesozoic sediments are now found at depths ranging between 1000 to 4000 meters. (Resanov, 1978) (Meyerhoff & Meyerhoff, 1972).

On Newfoundland's outer continental slope, there is unquestioned subsidence since Lower Cretaceous of 4000 meters. Shallow water reef limestones were encountered at the base of Newfoundland bank in drilling below 4000 meters, while on the Orpheus submarine Plateau farther east; non-marine Jurassic sediments were encountered at 2000 meters.

Near Iceland, subsidence is indicated in broad areas around the Faeroe Islands, the Rockall Plateau, and to the southeast in the Bay of Biscay. Along the submarine Rockall Plateau, sinking in M. Miocene is placed at 1400 to 2700 meters. In some areas, deep water sediments were found deposited above shallow water lignites and conglomerate.

In a hole drilled by the *Glomar Challenger* on Faeroe submarine ridge, Holmes (1965) reported lava less than 20 m.y. in age was erupted on land (not underwater). He concluded, consequently, the sinking of the ridge by 1300 meters took place in Miocene. This led to joining the Norwegian Sea with the Atlantic Ocean.

Farther south and east in the north Atlantic, major sinking in the Miocene is believed to have occurred in the Moroccan Basin and south of the Canary Islands (5000m & 4000m respectively). Lesser , or more recent, sinking occurred west and north of the Canary Islands where four large broad guyots, the *Atlantis*, *Plato, Cruiser* and *Great Meteor* guyots are found at depths between 180-455 meters. (Heezen, Tharp, and Ewing 1959).

NORTH ATLANTIC BASIN TABLE III

Location	Subsidence	Beginning in	Early Environment
Iceland-Faeroe Subm. Ridge	1300 meters	Miocene	
Rockall Submarine Plateau	1400-2700 m	Mid-Eocene	
Rockall Bank	900 m	?	
Bay of Biscay	2340-4400m	Lwr. Cret.	
Newfoundland Bank (base)	>4000 m	?	(shallow water, reef L.S.)
Orpheus Subm.Plateau	2000 m	late Cret.	Non-marine Jurassic seds
Blake Plateau (Florida)	3000 m	mid Cret.	
Moroccan Basin	5000 m	Miocene?	
N.W. of Canary Islands	180- 455 m	?	(four guyots)
South of Canary Islands	4000 m	early/mid Miocene	

The north Atlantic basin, the Equatorial Segment of the mid-Atlantic Ridge, and South Atlantic basin reflect three separate semi-independent depositional environments prior to changes that linked them together starting sometime in the Cretaceous (Patrunov, D.K. 1987).

15.0 THE PLATE TECTONICS HYPOTHESIS

"At any given moment, only a finite set of knowledge satisfies the reigning criteria for the formulation of scientific belief, and only this knowledge is eligible as truth. But the discriminating criteria are historically contingent; over time and across communities, they shift, they evolve, they are overthrown, they transmute."

Naomi Oreskes, 1999
(Introduction to: The Rejection of Continental Drift)

15.1 Introduction

The term *Plate Tectonics,* as presently used, includes a number of different concepts. In sum, it comprises several conceptual elements that make up the whole body of the Plate Tectonic Hypothesis—all essential to the total concept. Thus, the term is used by different speakers to explain different things.

If we examine the fundamental elements of this hypothesis which now permeates textbooks, papers, articles, and the thinking of Earth Scientists generally, it is seen that five physical mechanisms are fundamental to the hypothesis overall.

These are: Mantle Convection; Spreading Centers; Creation of New Oceanic Crust; Magnetic Striping; and Subduction Trenches. Some authors would also include continental "Drift" as an element of the P.T. hypothesis, relying, thereby, on crustal spreading as a driving force. This author believes that the question of continental "drift" is a problem quite apart from Plate Tectonics and should be considered separately.

Use of the term "plate(s)" as applied to Earth's crust seems a useful and valid concept to identify
the disparate physical characteristics of different areas of the surface that have evidently experienced unique histories and are usually bounded by major crustal rents or significant zones of lithologic or thickness change. The attachment of what often appear to be *ad hoc* mechanisms to the "tectonic" aspect of the hypothesis often presents the face of convenience and an unrequited faith in processes or mechanisms unproven by observation or repetition under accepted rules of the "Scientific Method."

Many authors who are believers in Plate Tectonics Theory define various individual plates and their geometry on the basis of several criterion: mid-ocean ridges, trenches, fault zones, associated zones of volcanism, and the location of earthquakes (These are reasonable criteria). It may be noted, however, that the number of plates (described in the literature) often changes from author to author.

Other authors also use as supporting evidence, calculations of the rate of "crustal spreading" in cm/yr based on magnetic striping, and, calculations of Eulerian pole movements.

Now I find it strange, if not illogical, that some of these authors later use the referenced features to "prove" the validity of plate tectonic theory. In other words, having defined the plates utilizing these features, the origin and causes for which in every case are only hypothetical, they now proceed to use the definition of plates, welding them to a series of questionable hypotheses, to prove "plate tectonics" as a valid theory.

If the San Andreas strike-slip fault is the eastern boundary of the Pacific Plate along the west coast of North America , and if the movement of ocean spreading is easterly (normal to the N.A. west coast) what is the driving force that moves the Pacific Plate *northward* relative to the North American Plate? Also, where are the compressional features one might expect to find associated with the San Andreas if this marks the Pacific and N.A. plate contacts? Something does not add up!

Here we encounter one of the frequent *ad hoc* hypotheses that offer an "explanation."
The north end of the East Pacific Rise is aimed up the Gulf of Baja Calif. The answer given is that the "spreading ridge" dives under the western edge of the North American Plate (Hoo boy!). This, if true, might account for the absence of compression related to the San Andreas (ignoring the coastal ranges) but should instead, be creating *tension* along the fault. The origin for a force that drives the (present) northerly slip movement, which some authors have said, will, in a few million years, move Los Angeles north to Alaska, remains unanswered.

How do "plate" supporters explain the marked difference in the orientation of Transform faults (or if you choose, "fracture zones") relative to major ridges postulated as "spreading zones" in different oceans?

Transform faults (in plate theory) develop as a result of different spreading rates along different segments of a mid-ocean ridge spreading center. This is supposedly "confirmed" by measuring the separations of magnetic "zebra stripes" in juxtaposed segments on either side of the faults. If true, it would seem that the majority of the transform faults should be oriented at nearly 90 deg. to the main trend of the ridge.

Along the Mid-Atlantic Ridge, the N-S ridge axis is offset at varying distances laterally by faults oriented at about ninety degrees to the axis. Some of these faults have been termed fracture zones. Whether the others are transform or strike- slip faults is not known.

The almost mandatory 90 degree orientation specified by spreading hypothesis does not hold true south of Africa and Madagascar where the Atlantic Ridge, is interpreted to swing east and then northeasterly to become the Southwest Indian Ridge. Here is mapped a pattern of faults consistently oriented at about 45 degrees to the main "spreading Center" ridge. The crest of this ridge appears to have little or no offset displacement in spite of the obvious fault pattern. There are also other major oceanic ridges where no faults ---transform or otherwise --- seem to be present. e.g. the Chagos and Ninety East Ridges in the Indian Ocean.
If the Southwest Indian Ridge is a "spreading center" characterized by transform faulting, how could this ridge have been formed by orthogonal spreading where faulting is oriented at 45

degrees and the ridge crest has no significant offsets? The posited mechanism of sea-floor spreading offers no explanation for this situation. It would seem that faulting would have to postdate the formation of the ridge. Similarly, the Ninety East Ridge and the Chagos Ridge are not easily explained by sea-floor spreading processes. Did these and other ridges form by some other mechanism(s)? It is clear that other hypotheses must be considered.

15.2 Mantle Convection

The concept of mantle convection is at the base of the Plate Tectonic "food chain." All predicated processes that follow are dependent upon some element of this idea.

Early speculative models of Earth's interior postulated multiple layered zones of semi-spherical shells developed outward from a dense core. Each zone was characterized by discrete physical qualities of density, composition, and physical state of solidity, plasticity, and liquidity, or some combination thereof. Subsequently, many zonal transitions were identified by seismologists and geophysicists who studied travel times and ray paths of earthquake waves to identify "discontinuities" in ray paths where these physical changes regularly occurred.

In view of episodic volcanism such as flood basalt, widespread surface volcanic activity, and the subsurface intrusion of dikes, sills, laccoliths, and batholiths scattered throughout most of post Archaean history, it was no great leap in thinking to suppose that the source of these volcanic manifestations arose in a sub-crustal zone not far below the lithified crust.

The two requirements were: 1) an ample supply of liquid magma, and 2) a force or mechanism to bring liquid magma (along with related gases and volatile liquids) to the surface. Since there is measurable heat loss through the crust, and there are other arguments for believing Earth has high internal temperatures, it was not difficult, initially, to supply both the material and the energy incident to volcanic processes.

Thus, the idea of convection currents came into the literature, first as speculation, then as hypothesis. There was no way either to demonstrate or to deny the existence of such mobile currents, but, they served to help explain geologic processes otherwise little understood. Repeated reference to "convection currents" in literature as components of discussions in scientific papers endowed the hypothesis with an aura of credibility that is unwarranted by hard evidence even today.

15.3 Convection and Geoid Anomalies

When considering the mechanics of convection in the mantle, it is critical that we understand and define what is meant by "convection."

Clearly, the term "convection", as it is used currently, implies a process driven by thermal energy. Thus, by using this term we forecast an element of the answer sought, and tend to foreclose consideration of alternative views on the observations made.

Seismologists who analyze the travel paths and timing of energy waves are basically seeking to identify anomalous deviations in these travel paths; then to interpret and assign physical reasons for the anomalies (Teisseyere, R. 1993). Localities and depths of density change are, of course, factors causing changes in wave velocity, transmission, and direction. Once such anomalies are noted, numerated, and mapped, the mind turns to interpreting these phenomena.

If an investigator enters the search oriented to asking the question, "do convection currents exist in the mantle?" At least part of the investigation is precluded at the beginning. It is thereby, tacitly assumed that the answer will be in some form of yes, no, or a qualified partial answer. Any "anomalies" in velocities, direction changes, etc. will be examined as a reflection of conditions imposed by convection, i.e. density, temperature, or other physical change attributable to the motion of convection----and, from here, an answer related to the question of mantle convection may be crafted.

This author contends that the investigator's question should be generalized and expanded to ask:
"What kind of wave anomalies exist within the crust and mantle; and, what physical conditions cause them?" This approach seems very appropriate to the skills of professional seismologists.
Here is the point at which the question of how these physical conditions came to exist should be asked. What is the over-all picture of heterogeneity in Earth's crust? What physical conditions cause them? The door is now open to hypotheses alternative to convection.

Answers need not be couched in terms of plate tectonic concepts where upward vertical motion is due to heat, and downward motion is due to the subsidence of "cold" oceanic slabs for which there is not a scintilla of surface evidence. By restricting the question to mantle convection, we skew the answers; some of which are essentially pre-ordained: areas of high velocity at depth become subducted cold slabs. Areas of low velocity nearer the surface are thermal up-wellings, etc.

Possible alternative explanations to at least some of the observations pondered by geophysicists may be afforded by recognizing the fact of Earth's increasing net gravity throughout the span of ascertainable Earth history.

It is here suggested that vertical movements in the mantle, lithosphere and crust may be attributable to forces other than convection; e.g. increasing net gravity in combination with horizontal stress and isostacy. The elevation of ridges and other crustal areas associated with elevated thermal conditions is not proof, or a definition, of thermal convection. Further, it would be desirable to restrict thermal convection to a clear definition that would distinguish this type of vertical movement from that which may be attributed to gravitation----and more specifically to the this author's concept of **gravitation density cells** which in concept have been operational throughout geologic history. Perhaps a more generalized phrase like *vertical gravitational transit*
could be used. That would cover forces attributable to either thermal or gravitational causes.

It may be noted that plotted anomalies of density, temperature, and undulations of velocity boundaries mapped by geophysicists at deeper levels of the Earth geoid (Teissereyre, Czechowski, & Kopystynski, 1993) are rounded in shape. No doubt this is an artifact of contouring based on limited data. Still, it is what one would anticipate to be reflected at deeper levels where high temperatures, liquidity, low conductivity and variations in viscosity are believed to prevail.

However, in the lithosphere and upper crust where the mechanical strength of less plastic, more rigid material becomes a factor, we observe few of these smoothed rounded patterns----or, other features reflecting large-scale vertical movement expected from thermal convection.

On the contrary, we observe feature after feature world-wide reflecting extended linearity: mountain chains; ocean ridges; trenches; faults and crush zones of every breed----all dominated by linear patterns. And, of course, there is the set of elevated "mid-ocean" ridges girdling the globe like the seam on a baseball. That is hardly a pattern expected from heterogeneous thermal convection.

How can it credibly be argued that linear surface patterns derive from anomalies at depth that are depicted as smooth, vary laterally with depth, and are devoid of sharp lateral boundaries? It would seem more reasonable to consider dynamic forces acting in the lithosphere that are capable of generating linear deformation.

Examples of other authors questioning the mechanism of thermal convection are worth noting here:

W.M. Elasser (1971) States:

> "The driving forces of any circulation in the mantle are both thermal and chemical. But, the proportion in which these contribute is largely unknown; very likely thermal effects dominate."
> ----" Some authors have presumed that the convective motions in the upper mantle are caused primarily by heating from below, but, there is no direct evidence for this."

Elasser goes on to propose a reverse kind of "upside down" convection where cooling of magma at the ocean-bottom/ sea-floor interface initiates sinking in the 'cold' upper layer.

A. Meyerhoff, et al (1992) in *New concepts in Global Tectonics:*

> "The Seismographic images by Dziewonski and Anderson (1984), Woodhouse and Dziewonski (1984 & 1987), Grand (1989), and Liu Jianhua et al (1989), demonstrate quite unmistakably that convection patterns like those predicted in plate tectonics do not exist."
>
> In addition, Sandwell and Renkins's (1988) studies of the geoid showed contrary to widespread belief, that there is no reflection in the geoid of large-scale mantle convection cells."
> ----"Today, great volumes of data especially those from seismotomography, are becoming available. No evidence for large scale convection is evident in these data."

H.W.Menard (1964) in *Marine Geology of the Pacific:*

In a discussion of possible origins of oceanic rises present in the Central Pacific, Atlantic, and Indian Oceans, Menard rejected serpentinization of the mantle (Hess, 1954), large scale expansion of the Earth. (Egyed. 1957), and continental drift (Heezen, 1960). He then comments on convection currents in the mantle:

> "We are left, at least for the moment, with the convection hypothesis. Convection in the mantle has been suggested to explain such diverse geological phenomena as the origin and present distribution of the continents and ocean basins—the formation of island arcs and geosynclines, and the high heat flow under the oceans."
>
> "Almost all of these phenomena have been explained in other ways, and the mantle may be stratified in such a way as to prevent convection. Consequently, the existence of convection currents is by no means proved." "I shall say now, ---if convection currents exist.... the reader may assume that this statement occurs in the text wherever he wishes."

Menard continues....and as he wrote the following paragraph, he must have nearly choked!

> "The convection hypothesis proposes that a mass of overheated material in the mantle begins to rise along a line roughly 10,000 Km long. Because it is hot or because of other changes, a bulge develops in the mantle which has topographic expression as a rise (Mid-ocean ridge) on the sea-floor."

15.4 Spreading Centers

This element of Plate Tectonics is conceived of as an oceanic ridge elevated by the rise of a hot convection current generated from an indeterminate heat source within the earth's mantle. Such ridges are dominantly linear and may extend, offset by orthogonal faulting, for many thousands of kilometers. (e.g. The Mid-Atlantic Ridge, the East Pacific Rise, and the South Indian Ridge). The concept states that molten magma exuding periodically at the ridge crest solidifies to form new oceanic crust. The new crust splits equally and is carried away in opposite directions by the convection current---also spreading in opposite directions beneath the crust, in the manner of a "conveyer belt" (Dietz, R. 1962). Oceanic Ridges, Spreading Centers, and Sea-floor spreading are discussed in more detail below and in Sections 16.0, 17.0, &18.0.

If convection plumes exist and are fundamentally responsible for a long history of crustal disturbances, it is extremely difficult to visualize a condition or mechanism that would result in producing the extensive linear structural features represented by mid-ocean ridges, deep ocean trenches, linear continental mountain chains, lengthy oceanic transform faults, major crush zones, rises, and in particular, world-wide oceanic basin subsidence.

Not all immense linear structural features are oriented generally N-S, and although these are dominant; many trend nearly E-W. The point is that linearity over great distances is hardly compatible with random internal turbulence in a liquid component of the Earth's mantle. This is particularly true if it is argued that convection currents are the fundamental generator of tectonic forces within the semi-rigid crust.

Moreover, if “convection cells” exist in the form postulated by plate tectonic theorists, they should have irregular, rounded shapes of considerable vertical relief. Additionally, the “cell” should delineate mobile material under, or in the vicinity of, the “spreading centers” which are said to result from, and are “evidence” of such cells. The subsurface identity of such a cell would be detectable by changes in its density, the physical character of its mobility, its temperature, the transmission of wave energy, etc. In any event, there would be a density variation related to the cell’s shape, which would be detectable to seismologists in tracing earthquake ray paths. Evidently, this condition has not been clearly observed to date.

Another consideration is the geometry of the mid-Atlantic Ridge and the East Pacific Rise. These have been mapped as generally N-S oriented features that are essentially linear and extend in nearly unbroken continuity for thousands of Km. What kind of convection cells, have this kind of shape?

Convection cells observed in boiling water or other heated liquids are rounded in shape and appear at random locations related to heat centers when viewed from the surface of the heated medium. Is there some unique mechanism within the Earth that concentrates these “cells” along generally N–S oriented linear paths? Or, is there some other tectonic mechanism controlling and producing these ridges? Perhaps it is the same mechanism which has produced the Cordilleran mountain belts of North and South America and the linear east-west ranges on other continents.

If convection in the mantle at localities of up-welling is sufficient to rip continents apart, and create “mid-ocean ridges” of a most unlikely geometry, that is, markedly straight and elongate for thousands of miles as exemplified by the Ninety East Ridge, the Chagos Ridge and others in the Indian Ocean, then logically we should expect to see features at points of down-welling that are of equivalent magnitude. Trenches do not fulfill this requirement.

A) Trenches are located only where so called “conveyor belts” are postulated to impinge sialic plate material (continents). Is this merely fortuitous?

B) Trenches are absent in places where they are to be expected along the margins of Africa, Australia, Antarctica, and the east coasts of North and South America.

C) Recognizable spreading centers in the Pacific Basin are too few to match the existing trenches. In the Atlantic Basin, there are no trenches to match the largest of postulated spreading centers, i.e., the Mid-Atlantic Ridge.

D) Trenches are not geometrically configured as one would expect if caused by down-welling.

E) Why are there no sites of convection subsidence in mid-ocean anywhere *within* delineated ocean plates,----- or well away from continental margins? (Mariana Trench may be an exception)

F) How is it that a mobile plate “bends and descends into the mantle only where there is a trench?

Are we dealing here with a phantom? Or, perhaps, as author Stephen J. Gould (1983) expressed his view of other questionable speculations, we may be dealing with "unconstrained feats of imagination."

*   *   *   *

15.5 “Convection”—Thermal or Gravitational?

The question is: Can we distinguish whether vertical movement in localized areas of the Earth’s crust and mantle is caused by heat energy or by gravity? How are ocean ridges created? Is the vertical movement giving rise to elevated “spreading centers”, other ocean ridges, or subsiding basins, attributable to:

1) Thermal energy that creates convective motion, or,
2) Gravity (increasing over time) acting on a body of material less dense or more dense than the materials below and lateral to it.

Before proceeding further these two cases must be defined:

1) In each case we are examining the kinetics of vertical motion, both up and down, in the upper mantle and lithosphere. It is assumed that all such movement is driven by pressure differentials related to the material density of a defined body relative to its surroundings. The body in question may be less dense than its surrounding material, thereby creating pressures causing it to rise. It may be more dense than its surroundings provoking pressures that cause it to sink. This density differential may result from relative temperatures, chemical composition, or material physical state.

Both cases require that we assume non-uniform physical conditions laterally in the mantle and/or in the lithic crust. Each case requires that these non-uniform (heterogeneous) conditions must result from non-steady state forces which change slowly through geologic time.

Thermal heterogeneities may result from many causes. These can include deep internal forces (movements) related to the earth’s genesis, materials motion, and thermal dissipation. These will change in magnitude and effect over millions of years due to lunar gravitation or to physical-chemical-mechanical responses in the lithic crust and upper mantle. An additional possibility is the localized generation of thermal differentials by radio-active decay. Many of these factors may not be knowable.

In any event, if thermal heterogeneity in the upper mantel is in fact a player producing convection, its location is migratory through time and dependent upon changes in an internal thermal regime. Guidance in its geometry and the location of its surface effects, must of necessity be controlled indirectly by secondary factors related to active forces and physical conditions in the lithosphere.
e.g. horizontal compression.

One thing we know with certainty. Thermal convection is dependent upon differential temperatures---a source of heat energy and a “sink” to dissipate or transfer heat ---- both operating in a steady gravity field. Heat increases volume and reduces density. The heat energy amplitude may vary but it must continuously maintain a temperature and density imbalance or the convection flow will cease. Dynamically, we are dealing with energy flow under conditions of imbalance.

2) Now look at the hypothesis of vertical motion controlled by gravity:

In this case the arguments for lateral heterogeneity in density distribution assumed in the thermal case are the same as stated in the first paragraph of 1), above. Nearly all of the other conditions set forth above also apply —except one—gravity.

We are still considering a discrete body wherein the body's density differs from its surroundings. The density state may result from chemical composition or temperature. This may initially develop in a number of ways----often as a result of relative movement driven by other dynamic forces including horizontal compression, gravity, isostatic adjustment, possible drift, or even an element of thermal energy. All the arguments for vertical movement related to density and pressures, cited above, apply where imbalances may exist. But, now there is a "wild card" in the game ----not considered in case 1), above.

This is the steady increase in Earth's net gravity. It is an irrefutable fact that there is, and has been, a constant increase in Earth's net gravity throughout most of geologic time (Proterozic to Present).
The gravity increase would, of course, also be operational in the thermal case. The important point is that a new door opens.

If we omit thermal convection from consideration by assuming either:

A) that no concentrated heat sources exist to create needed differential temperature conditions or that
B) there is a slow diminution and dissipation of any localized heat

We have a model that when the dynamic energy to create density differential and drive convection is absent or gone, vertical motion will eventually be suspended ----even though there may be remnant density differences attributable to chemical composition or lingering heat imbalances.

This brings into focus a dynamic force previously ignored: the constant increase in Earth's net gravity----increasing at a greater rate in the geologic past, though now slowing, but still effective.

Vertical movement in discrete large bodies of low and high density materials can be explained in terms of increasing gravity absent any requirement for "convection" related to temperature. Thus, it is the consistent increase in gravity that is the *dynamic force* driving vertical movement in heated materials (migrating into oceanic rises) and other low density materials in ridges. On continents, batholiths and the cores of granitic mountains will continue to elevate long after near surface materials solidify so long as lateral density differences exist at depth.

Discrete bodies of dense material comprising oceanic floors and the underlying upper mantle will sink as gravity increases for reasons that are obvious. This statement is well supported by the fact of general subsidence in all the world's oceans since at least early Jurassic. This includes lesser intra-ocean basins subsiding in ranges of 4000 to 5000 meters. Subsidence, however, is limited by the changing environment of internal temperatures and pressures at depth.

The above considerations force us to be more forthright in questioning the most basic underpinnings of Plate Tectonic tenets: i.e., convection, sea-floor spreading and subduction.
Recognition of increasing net gravity provides the possibility of understanding mechanisms not well explained by Plate Tectonics.

We return now to the original question: Is it possible to distinguish *thermal convection* from *gravitational "convection*", and if so, what are we dealing with in oceanic ridges?
The answer: Perhaps not yet. But, arguments for gravitational "convection" independent of a thermal component to drive movement are growing. This is not an argument to say that thermal convection, on some scale, does not exist.

Conventional mantle "convection" of large magnitude, if ever clearly demonstrated, would support sea-floor spreading and other aspects of the plate tectonic hypothesis. However, numerous observations suggest conflict with many attributions of thermal convection. Opposing this, recognition that gravity is the controlling dynamic of motion in density differentials would essentially show the plate tectonic hypothesis to be false. Conceptually, the creation of new crust and spreading of the sea-floor on "conveyer belts" is dependent upon thermal convection.

Alternatively, gravitation combined with compression may explain the elevation of ridges and archipelagoes along with basinal subsidence and deep oceanic trenches. The gravity hypothesis would open the door to a whole new way of synthesizing data and organizing research projects.

*   *

16.0 OCEANIC RIDGES & SPREADING

"To be accepted as a paradigm, a theory must seem better than its competitors, but it need not, and it never does, explain all the facts with which it can be confronted." "----but there are always some men who cling to one another of the older views, and they are simply read out of the profession, which thereafter ignores their work."

Thomas S. Kuhn, 1970
The structure of Scientific Revolutions

16.1 Introduction

There is a similarity in the methods employed by politicians and believers in "spreading centers" in that both groups often deflect discussion from a central problem or issue by centering on subsidiary matters while avoiding the real question. Politicians do this intentionally. I suspect that Earth Scientists may do this unconsciously, or because of belief that the real problem of oceanic ridges has already been solved and that only secondary or tertiary mechanisms need to be investigated and discussed. Thus it is with the matter of mid-ocean ridges and spreading centers. "Believers" think these concepts are settled facts, when they are not. This is "faith based" science.

A fundamental question posed by oceanic ridges, whether called spreading centers or just plain ridges, is how these features, extending for thousands of kilometers, form dominantly linear patterns. They are not, it is an absolute certainly; formed solely, or even principally, as a result of thermal convection in the Earth's mantle. The question of diapiric forces based upon differences in density induced by heat, chemical composition, or physical state is certainly worthy of consideration and further study. This, however, involves other physical considerations and it is a different 'breed of cat' than the idea of thermal convection. Mantle convection has never been demonstrated or proven, and ocean floor spreading is still a debatable issue.

While convection may, or may not, play a role in ridge formation, other factors such as horizontal compression, gravity, variation in lithospheric density, and mechanical strength must play dominant roles in ridge location, size, and construction. Volcanism (magmatism) related to these ridges is a secondary manifestation of the ridge-forming process. And, while volcanism often adds material bulk to many ridges, volcanism is not the *prima facie* force in ridge construction. What is the true mechanism? That is a question yet to be properly answered.

16.2 Sea Floor Spreading

Sea floor spreading of the oceanic crust is the bedrock foundation upon which the hypothesis of Plate Tectonics is grounded. Its various aspects, implications and mechanisms must, therefore, be examined carefully. If it's manifold characteristics and implications are in conflict with, or cannot be sustained by, physical observations and the laws of physics, then we must question its validity, along with the validity of closely related mechanisms tied to and dependent upon it.

These dependent mechanisms include: *Spreading Ridge Creation, Crustal Genesis, Subduction mechanics,* and spreading as a mechanism of force in *Continental Drift*. This means that if spreading as an agent in tectonic and crustal deformation cannot sustain critical examination, it must be rejected and discarded as false. This would include its relevance in compressional mountain building, sea floor subsidence, and continental epeirogeny.

This does not mean that presently, we must reject, out of hand, continental drift, or any of the other myriad manifestations of the dynamic forces at work in the Earth's crust.
i.e. those forces which have influenced four billion years of geologic history and, that ultimately, continue to affect most aspects of our environment.

This does, however, mean that we have no choice but to seek out and understand the true mechanism(s) that generate and govern these processes. To paraphrase a common saying in business—location, location, location, is a key to success. The key to truth in science is — mechanism, mechanism, mechanism. Unfortunately, today, with respect to plate tectonics, we are floundering about in a chaotic sea of speculation based on hypotheses constructed *ad hoc*, that are tied to mechanisms not clearly understood or demonstrated and where the only currency is repetition, repetition, repetition.

16.3 The "Mobilist" View of Plate Tectonics

The concept for spreading of the oceanic crust was first published about forty years ago by Harry Hess (1962) Almost simultaneously; "sea-floor spreading" was described in a paper by Robert Dietz (1962). Both were world-class scientists and good friends who may have jointly discussed then current data and beliefs to arrive at similar views. Hess, however, was credited with the idea as, under common practice, his paper was the first published.

These works appeared to answer a number of tough questions and quickly engendered great interest. Soon, thereafter, followed proposals to explain the source and mechanism for spreading and a means to dispose of excess areas of crust (subduction trenches). These ideas also provided a suggested manner of moving continents --- reviving, thereby, Albert Wegner's hypothesis of continental drift which had lain rather dormant for a number of years.

Now, along with the addition of a couple more *ad hoc* speculations such as plate rotation, and magnetic stripe anomalies, earth scientists, especially oceanographers, had a complete package of tools with which to solve nearly any geologic problem. They could rotate crustal blocks, move them wherever needed to fit the pieces of errant crust back in their proper positions in a gigantic continent named Pangea and thereby explain the distribution (and isolation) of plants and animals presently found on today's respective continents.

Here was a neat way to explain all sorts of problems that had perplexed earth scientists for years. Most researchers were happy, working to solve problems and publish papers with new solutions. It also allowed individuals to let their imaginations run free.

The postulated spreading mechanisms are all attributable to interpretation of structural features in oceanic crust— presently an area of about 130 million sq. miles. Only a tiny portion of this has been studied in depth or detail. Unexplained by these mechanisms are many geologic features on continental areas. The question of Continental Drift, at least in limited measure, remains open--- subject to a better understanding of degree and the force mechanism(s) for motion.

In their simplest form, the elements of "mobilism" in plate tectonics are as follows:

A) Thermal convection currents in the mantle rise beneath the lithic crust to create an elevated ridge. The current then separates more or less equally and spreads horizontally. Tension created in the crust at the zone of separation allows liquid magma (basalt) to rise in the zone of tension where it solidifies.
Continued lateral spreading in the convection current creates further tension at the crustal crest allowing the additional injection of magma into vertical zones of separation and weakness, thereby creating more newly minted segments of crust. As the process continues, the new crust, along with that created previously, is carried away orthogonally from this center of crust creation, (ideally, in equal measures) in a conveyer belt-like spreading process. The rates of movement, as determined by stripes of magnetic anomalies, are in the range of about 2.0 to 10.0 cm per year.

B) As the creation and spreading of crust continues over millions of years, a problem soon develops— too much crust for the sea floor space available! What to do?
1) Expand the earth's total surface area;
2) Crumple the new crust by folding and or faulting;
3) Push against and deform continental plate areas; or,
4) Allow the excess crust to return to Earth's womb by "subduction" trenches.

Since choices 1) thru 3) could not be supported by any reasonable evidence, subduction into the maw of huge gaping trenches became the obvious solution.

A part of the explanation for the subduction process was that the oceanic crust, hot and of reduced density when new, slowly cooled and became more dense in its multi-million year journey from the "spreading zone" until it approached a continental margin. There , fortuitously, the plate's cold dense state caused it to uniformly roll down and plunge into a subduction zone and thence into mantle from whence it came--- to be remelted and recycled.

But, as with many idealistic states of "Paradise",----- snakes eventually crept into this Eden. Hints of trouble began to appear. A few dissenting non-believers published papers from time to time pointing out things that didn't fit the template—observations that questioned the now widely accepted orthodoxy. But these renegades were largely ignored. The punch tasted good and the crowd partied on; repeating in print the ideas (with little solid evidence) of mantle convection, spreading, and subduction trenches again and again ---- how could new-comers to the scene believe this was wrong when these things were in black and white right before their eyes? So why not accept these "truths" and get on with the program?

Believers in the "New Tectonics", particularly the "sea-floor Spreaders" and the "continental drifters" have maintained that the present ocean basins are all floored with volcanic rocks age-dating less than 200 million years (Jurassic). This, it is tacitly implied, is about when *something* initiated the break-up of Pangaea, separating one gigantic landmass, into Gondwana, and Laurasia, which eventually split into multiple "jigsaw" parts, including the dispersed continental lands we recognize today.

The mechanism of that "*something*" remains a mystery hiding behind a black curtain we have not yet penetrated. It shields processes operative during the first four billion years of history and avails for study mostly that which has ensued post-Jurassic. There is little in Plate Tectonic concepts that permit us to speculatively reconstruct earlier geologic events.

The Jurassic, it seems was when a "new day" in Earth history was born; a time when "convection currents" ruled; and sub-sea ridges thousands of miles long created new basaltic crust to fill the voids created by drifting plates. Eventually, new oceanic crustal sheets spread to arrive along the margins of a continent where they sank rapidly in subduction trenches. Finally, the sheets heated, melted and reunited with the mantle at great depth for another cycle back to a new "spreading center."

Along the way, the aging "new" crust, while being subducted, somehow contributed to the formation of regularly spaced volcanoes set back about 100 miles from the continental plate edge (The Pacific "rim of fire").Numerous earthquakes—mostly above 100 Km.---- but, some as deep as 700 Km. were also generated. Finally, the process of genesis and spreading swept into the depths of the subduction trenches, all pre-existing oceanic crust (older than Jurassic).

We have long since passed the time when we can continue to ignore evidence that spreading of the oceanic crust in the manner presented is a false, failed, concept. "Subduction" trenches, as dependent, unproven, immobile, and flaccid features, otherwise created, are no longer needed as *ad hoc* measures to dispose of "excess" crust. Similarly, "spreading centers" are no longer needed or sustainable by the evidence.

These postulated mechanisms, all originally based on interpretations of structures in the oceanic crust, leave unexplained many geologic features on continental plates. The question of continental drift, at least in some measure, remains open----subject to a better understanding of degree and possible force mechanisms involved.

If the present ocean basins are all floored with "new" crust dating less than about 200 million years, what happened to the pre-existing crust that was present over the Earth's surface in all those areas other than Pangaea? Even if all other areas of Earth's surface were covered by ocean, that area had to be floored by some kind of older, pre-existing lithic crust. Paleozoic sedimentary sequences on continental plates prove that mountainous areas were present and had to be shedding debris into oceanic depositories somewhere along their margins.

The Continental Drift aspect of Plate Tectonic hypothesis basically postulates that present continents are merely scattered pieces of Pangaea that are approximately the same size and shape as when "rifting" first occurred; other wise they couldn't be fitted together like pieces of a jigsaw puzzle. This leaves more than 65%, or about 130 million sq. miles of the earlier crust to be accounted for. Only a tiny portion of our present oceanic crust has been studied in depth or detail.

The "Spreaders" would argue that this older crust has been chewed up and subducted. But, to argue that no traces of this vast area of older crust has not been preserved either along continental margins, or paved over and buried beneath younger flows and sediments in deep ocean basins, or to believe that the drifting and spreading mechanisms were so efficient as to destroy all vestiges of this pre-existing crust, is to defy logic. Surely, some of this original crust, extant only 250 million years ago, would still be preserved somewhere, and it appears that it has been ---- in the northwestern Pacific (Choi, D.R.1987, 1990). (see *The Great Oyashiio Paleoland* in Section 19.6, Critical Commentary on Subduction)

This simplified presentation of Plate Tectonics' mobile processes establishes physical aspects of the spreading hypothesis which must exist and prevail if the concepts are to stand.

* Oceanic crust on and in the vicinity of the crest of "spreading centers" like the mid-Atlantic Ridge must consist of geologically young rocks.

* There must be unquestioned evidence of increasing absolute age in oceanic crust as distance from a postulated spreading center increases. Magnetic age dating is not reliable proof of age. There is much we do not yet understand about magnetic anomalies.

* Crustal stress in the vicinity of a spreading source should be dominantly tensional.

* Subduction trenches must show geologic evidence of the subduction process in their geometry and in associated sediment accumulations.

These are the basic and absolute minimum requirements that must withstand repeated study and testing if sea-floor mobilism's aspects of plate tectonics are to stand. If any of the above requirements cannot be met and can clearly and repeatedly shown to be violated or absent, then the widely accepted elements of plate tectonic mobilism, including the forces of “drift” must be critically re-examined.

*   *   *

(This is incomplete) 10-13-03

16.4 Ridge Creation and Heat Flow 02-17-04

What possible mechanism in the mantle or crust can produce linear convection currents that would result in linear rises in the oceanic floor such as the East Pacific Rise or any of the other lengthy mid-ocean ridges around the world? It is a virtual certainty that if such thermal currents exist they are controlled by some other guiding force or mechanism such as deformation induced by compression or tension coupled with gravitation effects.

The presence of high heat flow measurements at the crests of such elevated ridges or rises is a consequence of the force causing the linearity and the elevation of the rise and not the underlying cause of ridge creation.

In other words, elevated heat flows and the common extrusion of liquid magma are the secondary symptoms or manifestations of a more fundamental mechanism. Elevated temperature on ridges is not proof that rises are formed by thermal convection----only that heated magmatic materials are, (or have been) present. How, why, and when did they get to the crests of these ridges? (Presumably from the level of the top of the mantle/base of the lithosphere interface)

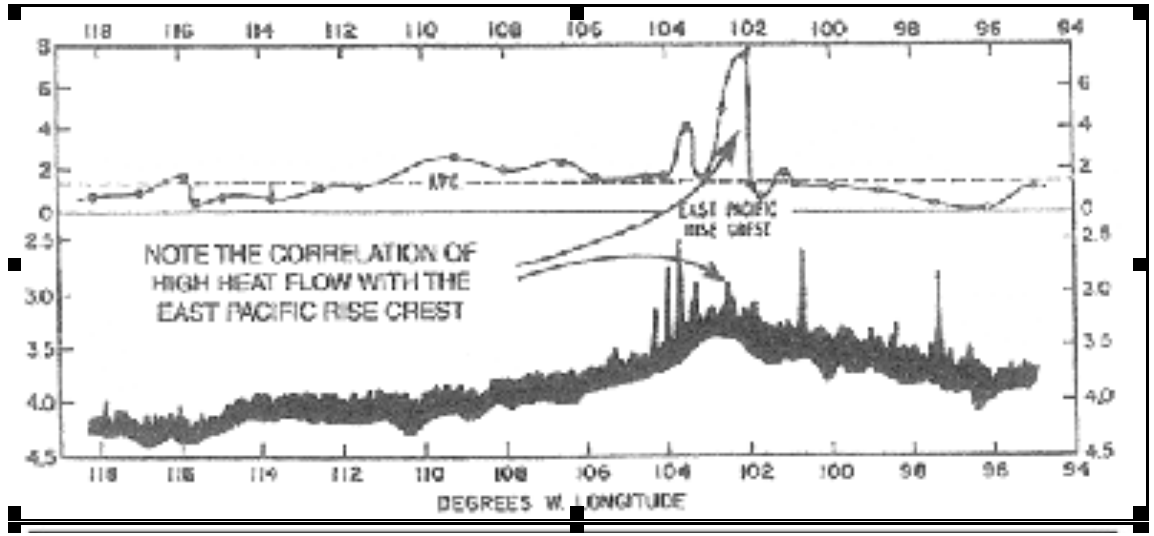
Figure 16.4.1, below, shows heat-flow values mapped along and near the East Pacific Rise. Sclater (2001) points out that while "values up to five times the average occurred near the crest of the swell"----"a number of average or below average values occurred within thirty miles of the highest values." This unusual distribution was not explained.

Map of heat flow stations with generalized 4,000 meter and 5,000 meter bottom contours. Note the high values (up to 8 cal/cm^2 sec). near the crest of the Rise. Close-to-average values (1.0-2.0 ca/cm^2 sec) elsewhere in the oceans; and the scattered low values that occur everywhere, even close to the crest of the rise. (After Von Herzen, R.1959)

Figure 16.4.1

Figure 16.4.2, taken from Von Herzen & Uyeda (1963) depicts a profile of the topography and heat flow measured across the East Pacific Rise. This clearly shows a correlation between the crest of the rise and a spike in the values of heat flow at the rise crest. However, is this not exactly where heated magma and other low density volatile liquids would accumulate considering relative elevations and the probability of tectonically generated pathways near the crest of the elevating grid?

Figure 16.4.2 Heat flow and topography across the East Pacific Rise. Note correlation between the high heat flow values and the rise crest. (Von Herzen, R.P.; and Uyeda., 1963. Heat flow through the eastern Pacific floor. *Journal of Geophysical Research* 4219-4250. Copyright 1963, American Geophysical Union.



We may now ask: Is the rise of heated, low density, magma and liquid along tectonically created pathway(s) to an elevated oceanic ridge crest exactly analogous to the accumulation of oil and gas at the crest of a sedimentary anticline? Are elevated heat flow anomalies along ridge crests analogous to oil and gas seeps?

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16.5 Lithologies Observed in Ridge Fracture Zones

The following figure 16.5.1 (from pg 70 of Mid-Ocean Ridges, Nicolas, A. 1995) shows a sequence of rocks recorded by the submersible NAUTILE during a dive along the Vema fracture
zone in the Atlantic.

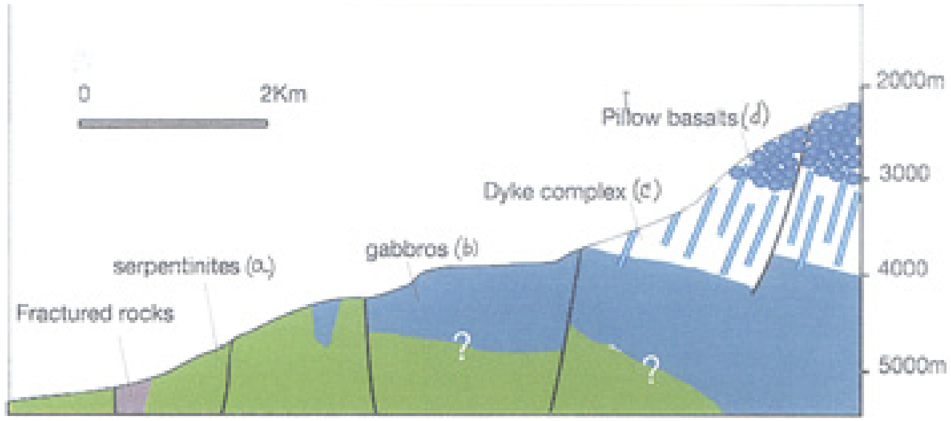


Figure 16.5.1

The figure shows (a) at bottom, a zone of serpentinites (and peridotites?). These are overlain (b) by a sequence of gabbros, above which is (c) a vertical dike complex; followed by (d) an interval of pillow basalt. (originally published in Nature, v337 pp 726-729.)

This is a rather common sequence of lithologies reported on or near mid-ocean ridges by other authors. (Tisseau and Tonnerre 1993) Let us speculate on how these rocks may have been formed.

1) The original oceanic rise (ridge) began to form by tectonic means, e.g. compression and differential density influenced by increasing net gravity.

2) A gentle welt or rise began to elevate, creating in the central crestal area, a number of fractures and minor fault and crush zones.

3) The original stratigraphic sequence consisted of the rocks in Fig. 16.5.1 (a) serpentinites, (& peridotite?), overlain by (b)basaltic mantle, (eventually becoming gabbro)

4) As the rise grew, the uppermost part of (b) the basaltic mantle (still liquid) began to cool and solidify at the top.

5) The rise began to form as a rounded crest (a large” anticline”) of existing oceanic crust ---while simultaneously, liquids emanating from the top of the deeper mantle began to accumulate.

6) As the rise grows, stresses in the chilled upper part of (b) the “basaltic mantle material” creates fractures allowing the lower liquids at this level to rise and start the formation of vertical dikes. Differential density aided by increasing gravity generates hydro fracturing for dike emplacement.

7) The continuation of this process creates an ever thicker and concentrated complex of vertical dikes-----essentially converting the upper part of the original basaltic mantle layer into what

has, or will become the vertical dike complex. (Thereby obscuring it's origin as the upper part of (b) the "basaltic mantle" layer).

8) At various points in time the dike complex erupts liquid basalt onto the ocean floor where rapid cooling from sea water creates flows of pillow basalt.

9) Tectonic forces combined with the gravitational factors related to gravitation density cells continues the elevation of the ridge. Slow cooling of (b) the basaltic mantle layer eventually converts it into crystalline gabbro.

10) The end stage, after millions of years, is a "mid-ocean Ridge" with topographic expression, high heat flow (from rising mantle liquids), eruptive basalt flows, and at numerous localities, a complex of ophiolite lithologies created at great depth, but, carried to the surface by density differences, and by mantle magma rising along a system of tectonically created fractures in a zone near the crest of the structure.

There is no reason to posit a single pathway or even several vertical pathways from the deep level near the top of the mantle. There could be a complex system of ruptured pathways feeding liquids to the crest of this ridge. And, while en route one would expect the emplacement of numerous dikes large and small, along with thick sills, laccoliths, and similar features. Some of this liquid magma, migrating from lateral sources at the mantle-crust interface, or created by en route melting, could move laterally for considerable distances toward the central area of the ridge where lithostatic pressure is least. All of these things would , of course, enhance the growth and size of the ridge laterally and vertically.

The foregoing also matches closely with observations near the axial domains of postulated spreading centers observed by other authors. The overall picture presented by Fig. 16.5.1 and the speculative steps, 1 thru10 following, compare closely in aspect with the relationships seen in the Hess Deep on the East-Pacific Rise, i.e. Gabbro overlain by sheeted dike complex, then pillow basalt and lobate flows. (Goff, Holliger, and Klaus, 2003. Chpt 4 102-103.).
All of this is essentially identical to the sequence along the Vema Fracture zone on the Mid-Atlantic Ridge.

> "The sheeted dike/gabbro contact is exposed for only about 4 km
> along the scarp, in the region of highest topographic relief."

If this author's suggestion regarding the migration of heated fluids and magma to the structural crest of ridges is correct, these relationships should be observed frequently.

Considering the third dimension, that of lengthy ridges extending hundreds, up to thousands of km in nearly straight and arcuate patterns, offset by transcurrent faulting, the controlling force is that of world-wide geocompression and the factors related to earth's oblate geometry. (Described in the section on Compression and Orientation).

* *

17.0 SPREADING EXAMINED #2 4-25-04

"Many precedents suggest the unwisdom of being too sure of conclusions based on the supposed properties of imperfectly understood materials in inaccessible regions of the earth."

Sir Edward Bullard

Royal Society Symposium, March 1964

17.1 The World Ocean Without Spreading

Convincing evidence against sea-floor spreading is presented by E.M.Ruditch (1990). The evidence is found at DSDP drill-sites in present-day deep water ocean basins. A significant number of boreholes found sections of deep-water sedimentation overlying Mesozoic shallow-water sequences at depth. This common relationship proves that shallow-water conditions prevailed early in the basin's development and that as it subsided, conditions transitioned into deep water sedimentation.

The work presents data so powerful it is best described in the original words of Ruditch:

> "Sections from 402 boreholes drilled in the Atlantic, Indian, and Pacific oceans contain evidence about a rather extensive distribution in the ocean of shallow water sediments whose age ranges from Triassic and Jurassic to Pliocene and Quaternary."
>
> "The peculiarities of spatial distribution in the ocean of shallow-water sediments and their vertical arrangement in some of the sections refute the spreading mechanism of formation of the oceanic lithosphere. This evidence implies that since Jurassic, oceanic depressions were formed as a result of large amplitude uncompensated subsidences of the crust. These subsidences occurred mosaically and had no connection with the system of rift ridges and rises."
>
> "As testified by Table I (p346), within the boundaries of the (Atlantic) ocean, the Mesozoic layers are mostly represented by shallow-water facies (in 72 of 80 boreholes); moreover, starting with Lwr. Cretaceous and down the stratigraphic scale, shallow-water facies are found in all boreholes, whereas deep-water facies are absent."

Table II (below), "shows from top to bottom of the (Atlantic)sections that occurrences of shallow-water sediments regularly increase, whereas the occurrences of abyssal deposits decrease regularly and then disappear altogether." (Ruditch pg. 347)

Facial Type of Sediments	Age of Sediments :	Q-N2	N1	P3	P2	P1	k2	K1	Jr	Tr
		NO. OF OCCURRENCES								
Shallow-water (or relatively Shallow-water) sediments		10	30	32	43	36	54	48	19	2
Deep -water sediments		163	121	83	62	39	27	2	1	--
Total:		173	151	115	105	75	81	50	20	2

"On the whole, the Pacific is similar to the Atlantic and Indian oceans in the absence of any obvious, regularly occurring dependence between the age of shallow-water accumulations and their positions with regard to the axial zone of the rift."

> "Finally, the prevalent confinement of shallow-water Mesozoic deposits in all three oceans to the modern abyssal zone is apparently caused by the steady tendency to uncompensated large amplitude subsidence of the bed in the oldest basins of the World Ocean."

> "Meanwhile, in the oceans the spatial distribution of shallow-water sediments is often directly *opposite* to that required by plate tectonics. In many cases, within the same blocks, the relatively younger sediments are found farther from the hypothetical axial spreading zones than the older sediments."

> "This distribution of shallow-water facies cannot be explained from the global tectonics viewpoint, and in actual fact it casts doubt on the verisimilitude of this concept in general and on the reality of spreading in particular."

A simplified summary of a lengthy series of complex data presented by Ruditch may be stated as follows:

1) A number of present-day deep-water ocean basins tested with boreholes consistently demonstrate sinking since lower Jurassic in amounts ranging from a few hundred meters to more than 5000 meters. Analysis of borehole data "provides no clue to determine the time of commencement of formation of oceanic depressions"----.

2) The oldest sediments at the bottom of deep-water bore holes were deposited under conditions of shallow water prevailing at, or near, the beginning of subsidence. Shallow- water conditions often continued during considerable intervals of subsidence, then transitioned into deep-water sedimentation during the remaining time of sinking and up to the Present.

3) These relationships were found in at least 19 boreholes drilled in 402 diverse locations in the Indian, Atlantic, and Pacific Oceans.

4) The transition from shallow-water deposition to deep-water deposition was found to be oldest in the Pacific. (Borehole sections analyzed: Pacific-214; Atlantic-173, Indian- 55)

Pacific Ocean	: Transition in 1st half of Cretaceous
Atlantic Ocean	: Transition in the Paleocene
Indian Ocean	: Transition in the Oligocene

Ruditch proposed that the vertical sinking may have resulted from "basification" of old continental crust. in localized regions. The term "uncompensated" used by Ruditch presumably refers to the idea that dense basic magma was injected into less dense overlying rocks, increasing their overall density, causing them to sink This is an idea much debated in the past but, never widely accepted.

If we turn to plate tectonics for a mechanism, we are no better off. The creation of spreading centers elevated by rising magma opens up a tangled "rats nest" of problems for which we presently have only a vague generalized concept. Thermal convection currents moving laterally with broadly uniform precision can by no stretch of imagination deliver vast areas of new crust to "subduction" trenches, while simultaneously performing feats of "mossaic" subsidence, elevating sea-floor ridges and island archipelagoes, and then subsiding again.

Acceptance of the slow increase in net gravity acting on areas of heterogeneous crustal density, causing thereby, subsidence in areas of more density, coupled with offsetting lateral flowage of mantle rock and elevation isostatically in less dense areas is easier to comprehend and more in keeping with known physical laws.

17.2 <u>Against spreading Center Concepts</u> 3-28-2000 9-02-03

Maps displaying the geometric regularity and precision of postulated bilateral spreading from linear spreading centers strike me as surreal and mechanistically improbable, if not impossible. Nothing I have ever observed in geology has ever deformed in such uniquely uniform patterns.
Very few exceptions to this come to mind.
.
a) Hexagonal columnar structure in cooling basalt flows.
b) Mud cracks in dry lake bottoms.
c) Polygonal ground in arctic tundra.
d) Hexagonal crystals developed in old ice.

The first two are associated with tensional stress, the next with repeated expansion and melting of frozen ground, and the last with crystal growth. I do not believe that tension is the dominant stress in oceanic crust.

The respected H.W. Menard (1969) sought to explain the active process operative at "spreading centers", but, his words seem to hinder more than support the concept.

> "The constantly repeated splitting of the new crust at the spreading center produces symmetrical continental margins, symmetrical magnetic patterns, symmetrical ridge flanks, and even symmetrical mountain ranges. More often than not, however, it has been found that the spreading center itself moves. Oddly enough such movement gives rise to the same symmetrical geology. All that is required to maintain the symmetry is that the spreading center move at exactly half the rate at which the plates are separating. If it moves faster or slower, the symmetry of the magnetic patterns would be destroyed."

Menard continues:

> "Since the material welling up through the fissure splits down the middle, half of it adheres to the stationary plate and the other half adheres to the moving plate."

This description defies logic and sounds absurd of the face of it. I doubt that Menard believed it. The crestal troughs of the Mid-Atlantic Ridge and others, are commonly described as ranging from 5 to 20 Km wide. They are enclosed by steep cliff walls rising to 3 Km (and more) above the present nearly flat central floors (Heezen and Ewing 1963). These troughs may extend for tens to hundreds of kilometers before being interrupted by offsetting strike-slip faults or transform fracture zones. The ridge overall continues for tens of thousands of Km. Any argument that present residual topography and geometry represents an interim stage of the precision process of spreading and magnetic stripe genesis described above, imposes a burden for qualities geologic processes rarely, if ever, display. In my view, Menard does an excellent job of demolishing the mechanisms proposed for these features. ----knowingly?--- or, unknowingly?

It is said that the "spreading centers" arise and are perpetuated by rising thermal convection plumes which create crustal tension pulling in opposite directions. Why is it that such plumes would create only uni-directional tension largely oriented orthogonal to linear plumes?
(a strange kind of plume).

If indeed, a thermal plume is active, why is there no dispersal of magma by injection into *transform* faults —converting them to spreading centers?

It is patently obvious that the majority of tectonic features around the world are oriented in generally north-south or east -west directions. These features include ocean bottom topography such as mid-ocean ridges, E-W transverse faults, most deep ocean trenches, the north and south Cordilleran ranges, and numerous sub-sea mountain ranges. Among the latter are the Ninety East Ridge and others in the Indian Ocean. The former, oriented due north-south extends more than 40 degrees of latitude.

Bullard, E., (1969) adds to the doubt and confusion:

> "What happens at the boundary of an ocean and continent? Sometimes, as in the south Atlantic, nothing happens; there are no earthquakes, no distortion, nothing to indicate relative motion between the sea floor and the bordering continent. The continent can then be regarded as part of the same plate as the adjacent ocean floor; the rocks of the continental crust evidently ride on top of the plate and move with it."

Wait a minute! 1) If there is no relative motion, how was the continent elevated and the sea floor depressed? 2) Why an escarpment at the edge of the shelf? 3) How do these two major physical features, ubiquitous world-wide, maintain themselves?

It is clear from modern multi-channel CDP seismic surveys and DSDP drill holes that the oceanic crust has been sinking world-wide since mid-Jurassic while the continental crust has, within limits, maintained reasonable stability.

Bullard finally concedes there are many implausible aspects of the sea floor spreading concept.

> "----a mass of detail needs to be filled in and many major features are uncertain."

The most powerful argument against sea-floor spreading is the lack of a rational explanation of how the process of creating new sea floor occurs. Dozens of authors accept that magnetic striping proves the "mobilist" hypothesis that new crust is generated at the crest of ridges created by mantle convection currents which create tension allowing oceanic crust to separate and permit liquid magma to enter a vertical zone or zones of weakness to create a new increment of crust.

The discovery and mapping of alternate magnetic stripes at intervals distant from the central zone of an oceanic ridge is taken as proof that the sea-floor has moved (or spread) orthogonally from this central zone. Many authors have written brief statements of how this mechanism of creation functions.

Some describe one principal fracture (or several) into which magma is injected, cools, and is then separated (equally) to move out in readiness for the next cycle of injection and creation. Others write of a zone of fractures along a primary central crest. Still others speak of a wide central zone ranging up to 20 km in width in which both injection and surface eruptions play a creation role. And some are satisfied to make generalized statements saying that new crust is created in a centralized area of the spreading zone crest as sub-crustal convection currents spread the new crust across the ocean floor in opposite directions.

Fred Vine, who along with Drummond Mathews and other premier scientists did remarkable work mapping magnetic stripes, and in developing the concept that magnetic stripes were evidence (even "unarguable proof") that the sea-floor was spreading, did not go into detail about the mechanisms of crustal generation. Rather, Vine was moved to write :(in Plate Tectonics, chpt. 3 p 62 2001, Oreskes, editor)

> "—the sea-floor not only spreads symmetrically about mid-ocean ridges but at an essentially constant rate, and in so doing, it faithfully records the time scale of reversals of the earth's magnetic field."

This statement is understandable but unfortunately it reflects the general acceptance that sea-floor stripes have come to enjoy as being proof of spreading but without an adequate understanding of the details of the mechanism by which magnetic stripes are created; and----as some wise person once said, "the devil is in the details!"

Beloussov (1970) points out, for example, that:

> "Any semblance of symmetry vanishes most definitely in the case of detailed

magnetic measurements with an instrument lowered to a great depth where the magnetic field disintegrates into an enormous number of small ovals arranged in echelon like fashion (Hertzler and Pichon 1965; Loncarevic and Mason 1966; Luyendyk and Melson 1967; Van Andel and Bowin 1968)

*   *   *

17.3 Mantle and Lower Crustal Rocks Exposed in Oceanic Ridges

Results of a symposium on the petrology and genesis of crystalline mafics exposed in central oceanic ridges and in ophiolites on land were summarized in seven papers edited by Vissers and Nicolas (1995). The localized mélanges of oceanic rocks studied have wide acceptance as being genetically equivalent to ophiolites exposed on land. Both are considered to be generated near the lower crust/upper mantle interface in a plutonic environment. Because these rocks of deep origin now occur at the surface along oceanic ridges regarded as magmatic "spreading centers", they are anomalous to standard concepts of new crust generation and spreading.

However, not all lithologies present in ophiolites are formed at plutonic depths. Spooner and Fyfe (1973) in a detailed study of the mineralogy and petrology of ophiolites at E. Liguria, Italy found evidence of hydrothermal metamorphism related to geothermal systems involving convective circulation of heated sea water. The metamorphic alterations were attributed mostly to near surface zones where brine temperatures were in a range of 200 to 400 degrees C. These processes included the solution of low concentration elements in basalt and other mafics; then re-mineralization at shallower depths, and discharge of dissolved and colloidal materials such as heavy metal sulfides at surface vents.

They concluded that: "vigorous convective circulation of brine within the oceanic crust is a significant process at axes of sea-floor spreading."

The lithologies in continental ophiolites compare closely to the lithologies described as occurring on ridges, walls, and central depressions of ridges described as "spreading ridges", i.e. on the Mid-Atlantic Ridge, S.W. Indian Ridge, Central Indian Ridge, East Pacific Rise, etc. ---- also, the same lithologies were sampled by submersibles, drill holes, and dredging in the walls and deep trenches of fracture zones and transform faults in oceans around the world. Tisseau and Tonnerre (1995) cite forty six oceanic ridge localities where mantle and ophiolitic rocks have been described. (Tables 17.4A, B, &C)

Not only are the lithologies much the same in all these localities, e.g. Mafics, ultra-mafics, peridotites, gabbros, harzburgites, serpentine and many others attributable to genesis in the lower crust/upper mantle, and the plutonic realm generally, but, the physical stresses and temperatures to which these rocks are interpreted to have been subjected are also nearly identical in equivalent zones in ophiolites. The texts (and photos)describe mylonites, ultra-mylonites, fractures, vein offsets, dikes, micro-dikes, various states of metamorphism, plastic ductility, foliation, solid dry deformation, molten injections, etc. —formed at temperatures in a range of 1000 to 800 degrees centigrade, and less, over millions of years.(Vissers and Nicholas *op cit.*)

There is also considerable discussion of heating/melting cycles with long periods of cooling and quiescence— along with the melt yields involving extraction of basaltic, gabbroic, and other lithic derivatives from <u>some</u> source of supply during the peaks of the heat-melt intervals.
The ridges discussed were deemed to be "fast spreading" or "slow spreading." The resultant interpretations were thus based on these *a priori* assumptions. There were no discussions of how

this spreading rate was determined —but, presumably it was based on magnetic striping.

The authors of every paper (seven) in this series— without exception— premised their interpretations of data on the assumption that the ridges bearing these rock assemblages were, are, or had been, spreading centers, or, related thereto in fracture zones and transform faults. It was always stated that mylonites were sheared by "extension"—never by compressive stress.
The petrology of ophiolites exposed in Oman (Saudi Peninsula) and Italy, and in the western Alps where the ophiolites are present as major thrust sheets, is remarkably similar to lithologies in the oceanic ridges.

There was no discussion of any alternative hypothesis as to the genesis of the ridges or how these widely distributed locales bearing lithologies seemingly birthed under conditions attributable to upper mantle/basal crustal depths came to be exposed at the surface of ocean basins. The forgoing observations generate some obvious questions:

a) If "spreading centers' operate on a basis of heating/melting and quiescent (cooling) cycles over millions of years, what is the source of this heat—and— why is it, or why should it be cyclical?

b) What is being melted to supply the vast volumes of oceanic crust postulated by "spreaders" to have formed and spread out over 65% of the Earth's surface?

c) If some material zone near the basal crust/ upper mantle interface is the melt source for the oceanic crust's spreading upper surface, why is there any necessity to dispose of this volume of material in subduction trenches? We would simply be dealing with a transfer of basaltic/gabbroic material from a lower level of the crust to a higher level—quite easily accomplished geometrically, by internal shifting and deformation.

d) If thermal convection in the mantle is the driving mechanism for creating oceanic ridges and spreading centers; which then transport newly formed crust laterally to subduction zones for disposal— it follows that any convection currents must consist of mobile material that is either molten, nearly molten, or in a highly plastic state. Why then, we may inquire, is it necessary to postulate cycles of heating and melting to bring about "spreading" and the conditions where ophiolite type lithologies are found exposed on rugged sea-floor topography near the crests of ridges and in deep canyons of fracture zones? Why is not the magma for these "spreading" centers assumed to emanate from the convection current responsible for the elevated ridge?

The question of how these mafic and ultra-mafic rocks— nurtured at depth— arrive at ocean ridges on the sea floor was addressed in a suggestion by Constantin et. al. (1995):

> "In search for complementary mechanisms other than purely tectonic uplift or diapiric serpentinization to explain the exposure of upper mantle rocks on the sea-floor, we propose as a tentative hypothesis that intrusion of gabbroic melts into upper mantle peridotites could play a triggering role in mantle exhumation. Intrusions occur early in the accretion process and possibly concurrently with tectonic uplift. Extensive basaltic intrusion will tend to

> lower the mean density of a given volume of upper mantle rocks affected by the intrusion. Batiza and Niu (1992) calculated densities of EPR 9 deg 30' N melts of around 2.7 g/cm^3, which is much lower than the mean oceanic mantle density of 3.3 g/cm^3 calculated by Solomon and Toomey (1992). Even a crystallized gabbroic melt has an average bulk density of 3 g/cm^3 as reported for Hole 735B gabbros (Dick et al 1991), which is still lower than the mantle average. We suggest that by virtue of their low density and brittle behavior, these gabbroic bodies inside the peridotite constitute preferential zones of weakness favoring localized faulting by which entire massifs are brought to the sea floor."

The mechanism suggested in Constantin's hypothesis fits closely with the mechanism for diapiric movement proposed by many other authors. It is also essentially identical to this author's concept of gravitation *density cells,* as literated in Section 9.0. The only element missing from Constantin's and other proposed diapiric mechanisms is the recognition of Earth's slowly increasing value of gravity. That is a critical factor.

More recently, two icebreakers equipped for research, performed high resolution mapping and sampling of Gakkel Ridge in the Arctic Ocean Basin near the North Pole (AMORE Expedition 2001).The initial findings reported by a team of American and German Scientists in *Nature*
(Micheal, P.J. et.al. 2003) place additional constraints on previous concepts involving ocean ridge spreading, volcanism, and the emplacement of plutonic lithologies, along all oceanic ridges.
In particular, they found significant conflicts between postulated spreading rates and predicted processes and conditions related to "fast" and "slow" spreading rates determined on major ridges around the world.

> "These observations from the Gakkel Ridge provide important new constraints on many aspects of mid-ocean volcanism."----
> "Investigation of the ultra-slow end member of the ocean ridge system therefore clearly documents the importance of variables other than spreading rate for all aspects of the behavior of ocean ridges. A multi-dimensional perspective will be essential for quantitative modeling of the diversity of ocean ridge processes."

17. 4 Sub Oceanic Precambrian Crust:(?)

Rocks of both Archean and Proterozoic age are reported present on the Rockall Bank south of Iceland. (Roberts, et. al., (1973) This is a large area of submerged Precambrian rock within what is termed a mini-continent between southern Greenland and the British Isles. While this area of ancient crustal rock may be relatively thin, its presently submerged state illustrates two points:

1) Areas of "oceanic crust" older than Jurassic (200 m.y.) still exist and have not been devoured in the maw of subduction.
2) Subsidence of ocean basin crust in epeirogenic gravitational-density episodes is probably controlled by the over-all average density of the lithospheric sequence in a specified region. This, of course, could include thin layers of old continental rocks of relatively low density underlain by a thick interval of more dense mantle rocks.

It should be mentioned also, that since Iceland is put forth as the prime example of a "hot spot' sitting astride the mid-Atlantic Ridge a short distance west of the Rockall rise , it is strange that the latter has been able to avoid being spread easterly and subducted.

TABLE 17.4A
MANTLE ROCK EXPOSURES AT THE ENDS OF RIDGE SEGMENTS ON THE MID-ATLANTIC RIDGE

After C. Tisseau and T. Tonnerre

Table 1. Observations of mantle rock exposures at the ends of ridge segments. FZ: Fracture Zone, MAR: Mid-Atlantic Ridge.

Locations		*Full rate (mm/yr)*	*Description*	*References*
Unnamed FZ	MAR/79°N			Michael and Bonatti, 1985a
Gibbs FZ	MAR/53°N	26	North and south walls	Hékinian and Aumento, 1973
				Michael and Bonatti, 1985a
				Dick, 1989
Unnamed FZ	MAR/43°N			Phillips et al., 1969
				Thompson and Melson, 1972
B FZ	MAR/36°30'N	22		Dick, 1989
Oceanographer FZ	MAR/35°N	26	East intersection	OTTER, 1984
				Michael and Bonatti, 1985a
Atlantis FZ	MAR/30°N	26	North wall and near top of crestal mountain	Miyashiro et al., 1969
				Michael and Bonatti, 1985a
Kane FZ	MAR/24°N	30	North and south walls	Miyashiro et al., 1969
				Michael and Bonatti, 1985a
			North and south walls	Dick, 1989
Fifteen Twenty FZ	MAR/15°20'N	22	East intersection	Rona et al., 1987
Vema FZ	MAR/10°N	24		Bonatti et al., 1971
				Thompson and Melson, 1972
			North and south walls	Honnorez and Kirst, 1975
			South wall	Prinz et al., 1976
			North and south walls	Bonatti and Honnorez, 1976
				Michael and Bonatti, 1985a
			Deepest part of transform valley and south wall	Lagabrielle et al., 1992
St Paul FZ	MAR/1°S		West and east intersections	Bonatti et al., 1971
				Thompson and Melson, 1972
Romanche FZ	MAR/2°S	33	North wall	Melson and thompson, 1970
			North and south walls	Bonatti et al., 1971
				Thompson and Melson, 1972
			North and south walls	Honnorez and Kirst, 1975
			North and south walls	Prinz et al., 1976
			North and south walls	Bonatti and Honnorez, 1976
				Michael and Bonatti, 1985a
Chain FZ	MAR/3°S		North wall	Bonatti et al., 1971
Unnamed FZ	MAR/4°S		South wall	Thompson and Melson, 1972

TABLE 17.4B
MANTLE ROCK EXPOSURES AT THE ENDS OF RIDGE SEGMENTS:
CENTRAL INDIAN RIDGE; S.W.INDIAN RIDGE; AMERICAN
ANTARCTIC RIDGE; AND EAST PACIFIC RISE.

From: C. Tisseau and T. Tonnerre

Table 1 continued. Observations of mantle rock exposures at the ends of ridge segments. FZ: Fracture Zone, CIR: Central Indian Ridge, SWIR: South West Indian Ridge, AAR: American Antarctic Ridge. EPR: East Pacific Rise

Locations		*Full rate (mm/yr)*	*Description*	*References*
Owen FZ	CIR/10°N		40 km SW of intersection with Carlsberg Ridge West wall	Hamlyn and Bonatti, 1980 Bonatti et al., 1983
Vema FZ	CIR/9°S	32	North and south walls	Engel and Fisher, 1975
Argo FZ	CIR/13°30'S	36	North and south walls Deepest part of transform valley	Engel and Fisher, 1975
Marie Celeste FZ	CIR/17°30'S	42	North wall, deepest part of transform valley	Engel and Fisher, 1975
Bouvet FZ	SWIR/1°E	14	West wall	Dick, 1989
Islas Orcadas FZ	SWIR/6°E	14	South-east wall	Dick, 1989
Shaka FZ	SWIR/9°E		East wall	Dick, 1989
S FZ	SWIR/14°E	14.4	South wall	Dick, 1989
DuToit FZ	SWIR/25°30'E	16		Dick, 1989
Bain FZ	SWIR/32°E			Dick, 1989
P. Edward FZ	SWIR/35°E	16		Dick, 1989
Discovery FZ	SWIR/42°E			Dick, 1989
46°E FZ	SWIR/46°E	14.8		Dick, 1989
Atlantis II FZ	SWIR/57°E	14.5	Median tectonic ridge East and west walls	Johnson and Dick, 1992
Melville FZ	SWIR/62°E	16	West wall South at 10-24.5 Ma	Engel and Fisher, 1975 Bassias and Triboulet, 1992
Bullard FZ	AAR/7°W	18	South-east wall	Dick, 1989
Vulcan FZ	AAR/16°W	18	North wall	Dick, 1989
Garret FZ	EPR/13°28'S	180	Deepest part of transform valley	Hébert et al., 1983 Cannat et al., 1990a Bideau et al., 1991 Hékinian et al., 1992
Iti FZ	EPR/24°13'S	120-150		Constantin et al., 1995
Heezen FZ	EPR/55°S	88		Lonsdale, 1986

TABLE 17.4C

OBSERVATIONS OF MANTLE ROCK EXPOSURES INSIDE RIDGE SEGMENTS: MID-ATLANTIC RIDGE; CENTRAL INDIAN RIDGE; S.W. INDIAN RIDGE; AND EAST PACIFIC RISE

After: Tisseau and Tonnerre

Table 2. Observations of mantle rock exposures inside ridge segments. MAR: Mid-Atlantic Ridge, FZ: Fracture Zone, CIR: Central Indian Ridge, SWIR: South West Indian Ridge, EPR: East Pacific Rise.

Locations	*Full rate (mm/yr)*	*Description*	*References*
MAR/39°N	20	DSDP site 556, west at 35 Ma	Michael and Bonatti, 1985a and b Juteau et al., 1990b
MAR/37°N	22	DSDP site 334, west at 8.9 Ma	Shipboard Scientific Party, 1977 Hodges and Papike, 1977 Juteau et al., 1990b Girardeau and Francheteau, 1993
		DSDP site 558, west at 37 Ma	Michael and Bonatti, 1985a and b Juteau et al., 1990b
MAR/34°N	26	DSDP site 560, west at 12 Ma	Michael and Bonatti, 1985a and b Juteau et al., 1990b
MAR/26°N	26	East at 3 Ma	Tiezzi and Scott, 1980 Michael and Bonatti, 1985a
MAR/22°45'N-24°N	30	West wall, 30 km south of Kane FZ	Karson et al., 1986 and 1987 Mével et al., 1988 and 1991 Karson, 1991
		ODP site 670, west wall, 45 km south of Kane FZ	Karson et al., 1986 and 1987 Shipboard Scientific Party, 1988 Cannat et al., 1990b Juteau et al., 1990a and b Karson, 1991
		DSDP site 395, west, 6.5 to 7.2 Ma, 90 km south of Kane FZ	Arai and Fujii, 1979 Boudier, 1979 Sinton, 1979 Michael and Bonatti, 1985a Juteau et al., 1990b
MAR/16°52'N	26	East wall	Cannat et al., 1992
MAR/15°37'N	26	Top of the east wall and west wall	Cannat et al., 1992
MAR/8°N		Pillsbury P6903-28, east (?) wall	Bonatti et al., 1971 Bonatti et al., 1975 Michael and Bonatti, 1985a
CIR/12°25'S	36	East wall	Engel and Fisher, 1975
SWIR/7°34'E	14	Wall	Dick, 1989
SWIR/13°07'E	14.4	Small rift valley high	Dick, 1989
Cayman R/18°N and 18°20'N	20	East and west walls	CAYTROUGH, 1979 Stroup and Fox, 1981 Malcolm, 1981 Ito and Anderson, 1983
Mathematician R/17°N	< 43		Vanko and Batiza, 1982
EPR/02°15'N	130-135	Hess deep, North wall, at 1Ma	Rudnik, 1976 Kashintsev et al., 1982 Francheteau et al., 1990 Girardeau and Francheteau, 1993 Hékinian et al., 1993

17.5 Other Arguments Against Sea Floor Spreading

Many authors have presented damning evidence on this subject. Below are some selected as most significant.

(James, P.1994) "Slab pull": is defined as a force deemed to be drawing the cold dense oceanic crust downward into the lithosphere and upper mantle through negative buoyancy. This presents a problem since the density of the oceanic slab (though now supposedly "cold") is less than that of the lithosphere and mantle it is supposed to penetrate.

The St. Peter and St Paul Rocks (Atlantic Ocean- 0 deg 56min N lat, 29deg 22min W long)
(James 1994) consist of two barren islands composed of metamorphosed ultra-mafic rocks. They sit close to the crest of the Mid-Atlantic ridge. Their ages are dated at 100 to 800 million years. Sediments deposited on their slopes are dated at 15 to 30 Ma. Clearly, these rocks are out of place considering their location near the crest of a spreading center. The locality is also reportedly underlain by a peridotite-hornblende-gabbro intrusion dated 835 Ma (Melson et al 1972) and confirmed by U.Cordiani.

These ultra-mafic rock types suggest genesis in part of the deep upper mantle complex similar to those exposed at 46 other locations reported along fracture zones and spreading ridges in the Atlantic (MAR) and Indian oceans, the East Pacific Rise, and the American Antarctic Ridge .
(Tisseau, C. & Tonnerre, T. 1995). The lithology and interpreted genesis also compares closely,
to two areas of ophiolite in N. Italy, an ophiolite in the West Alps (Caby, R.1995), and one in Oman, Arabian Peninsula (Vissers and Nicolas, Eds. 1995).

Sea of Japan Basin
Choi, D.R. (1984) reports that magnetic anomaly patterns found in the Japan basin correlate with major fault zones present in the surrounding continental areas. Based on seismic data, Choi also interprets the basin as being underlain by continental crust containing Paleozoic marine rocks.

Oyashio Paleoland -East of Kuril-Kamchatka Trench, N.W. Pacific
Choi, et al (1992) reports: "crust beneath the NW Pacific Ocean is not composed of oceanic crust, but is formed of Archean and Proterozoic continental crust". This is based on deep penetration reflection seismic profiles, dredging, drill holes, and correlation with seismic stratigraphy in the Sea of Japan. Seismic records show continental crust is present on both sides of the Kuril- Kamchatka Trench, and passes across it. These interpretations require fundamental revision of plate tectonic models for the geologic development of the island arcs and trenches in the NW Pacific region.

Labrador Sea (Grant, A.C 1980)
Magnetic stripes on the sea floor between Labrador and Green land have been used to support proposed strike-slip continental drift separating the two areas by up to 400 Km. Subsequent geologic field studies in the Nares Strait area reveal that no evidence of drift separation is present. "Pre-Cambrian and Silurian marker beds traceable across the strait allow for maximal strike slip movement of 15 km."

East African Rift: James (1994) reports no information supporting incipient ocean development or up-welling of magma along this rift. Continental crust, not oceanic, is found at the base of the rift. Furthermore, he states, "the rift system is aligned along a Pre-Cambrian fault system that can be explained as a normal tensional feature within the crust." In contrast with this latter interpretation, it must be mentioned that Hast (1973) reported, on the basis of drill cores, finding only evidence of high vertical shear, but no tensile stress in an area of Zambia only 40 miles from part of the African Rift.

The Red Sea (James, 1994) The Red Sea is reported to be a rift that commenced spreading in the Cretaceous, then in the Miocene the basin dried out depositing several km. of salt. Within the basin, pre-Cambrian ultra-mafic islands ("the Brothers") with lithology comparable to St. Peter and St. Paul Rocks on the Mid-Atlantic Ridge are present. If spreading has produced the Red Sea depression, it is hard to explain the location of these rocks where new crust should be forming.

It is interesting to note, also, that Miocene dessication and salt deposition appears to correlate chronologically where similar conditions (DSDP leg 13) are demonstrated to have occurred throughout the Mediterranean Basin in Miocene time below the Mio/Plio transition (Hsu 1983).

Iceland

Along the S.W. coast of Iceland the M.A.R. crest emerges onto land. This condition should 'create a prime area to inspect the ridge and lay bare its secrets'. James (1994) cites Sigurdsson (1968) as having found xenoliths of sandstone and dolomite within surface lavas on Iceland. Supposedly these lavas are extruded from sources in the mantle. This suggests that the sedimentary fragments were obtained from sediments penetrated by the lavas on their way to the surface. This does little to support a concept of a ridge built up of young basalts emerging to create new crust and spread it laterally in a developing North Atlantic Ocean basin. Moreover, surface structures on Iceland are indicative of compression, not tension as predicted by spreading.

Here we can inject Belussov's (1970) observations on Iceland as a test of spreading from Reykjanes Ridge, but in deference to the reader, only his conclusions related to magnetic anomalies will follow.

A series of magnetic profiles mapped across submarine Reykjanes Ridge south of Iceland were compared with aeromagnetic profiles flown in parallel at comparable spacing on-shore Iceland to the north. Similar points of anomaly were identified and compared with the age of basalts at distances of about 80 miles on each side of the axial crest. These anomalies should have corresponded to an age of 8 million years based on magnetic dating. But, they fit strips of Pleistocene volcanoes that gave ages the same as the axial zone of the submarine ridge.

Belussov's final observation on Iceland's contribution to the concept of crustal spreading were:

> "This result blasts all conclusions concerning 'fossilized magnetic epochs' in the structure of mid-ocean ridges."
>
> "We may conclude that a comparison of the structure of the submarine ridge (Reykjanes) and its land surface continuation results in a complete fiasco for the hypothesis of ocean floor spreading." (1)

Studies by Bodvarsson and Walker (1964) involved counting and attempting to correlate the number of Icelandic dikes with a mechanism of lateral extension but, their results were not convincing.

Less well documented, but noted in the literature are other examples of apparently exotic rocks associated with basaltic oceanic crust. On Easter Island (Pacific Ocean) short flows of rhyolitic obsidian were mapped by M C. Bandy (1937). Exotic sialic clasts have also been observed on Fiji Island..
Ascension Island perched on the crest of the supposedly basaltic Mid-Atlantic Ridge is another anomaly. Darwin first discovered granite bombs on Ascension 'thrown up from below the original sea bottom and incorporated in the tuffs and breccias'. This was confirmed subsequently by R.A. Daly (1925). (See Gutenberg, B.1939 p.45)

In the Indian Ocean, there are similar inconsistencies in lithologic occurrences posing questions to standard "spreading" concepts: On Carlsberg Ridge, Proterozoic and Paleozoic igneous and metamorphic rocks are found. Granites are part of the Seychelle Isls. platform. The crest of Ninety East Ridge yields abundant metamorphics.

Moreover, if spreading centers are the co-partners of trenches creating new crust to feed and sustain them, where pray tell is the spreading center for the Java Trench south of the Sunda Arc? The continent of Australia lies but a short distance south of the trench, effectively precluding the presence of a spreading center that could "feed" it. Nor, is there evidence that a spreading center may underlie the northern margin of Australia since stress measurements and surface deformations indicate the entire Australian continent is in a state of "substantial horizontal compression." (Denham, Alexander, and Worotnicki, 1979). This view of compression was later supported by Antiloff (1992)

* * * *

Footnote (1):

This is an absolute <u>MUST READ</u> paper for any objective researcher.

BELOUSSOV, V. V. (1970) Against the Hypothesis of Ocean-Floor Spreading.
Tectonophysics Vol 9 No 6 489-511

Beloussov presents pages of logical, well written, scientifically based arguments against sea-floor spreading. These arguments oppose a wide spectrum of the reasons pro-spreaders offer as positive evidence ----particularly, magnetic anomalies. The present author could hardly improve on this.

18.0 MAGNETIC ANOMALIES

"It is within Man's power to content himself with proofs that he has,
if they favor the opinion that suits with his inclination or interest,
and so to stop further research."

John Locke 17th century Philosopher

18.1 Introduction

A major difficulty this author has with "sea-floor spreading" from central oceanic ridges is the postulated symmetry of magnetic stripes on either side of the theoretical spreading center. The apparent (as depicted) balanced uniformity of alternating "normal" and "reverse" magnetic polarity stripes on either side of the central ridge where new crust is created is almost totally without an understandable or explainable mechanism.

No explanation that I have yet read makes any sense geologically. Most writers ignore the problem of mechanism. Instead, they rely primarily on citing the apparent existence of the interpreted stripes as being proof that some poorly understood mechanism divides, equally, up-welling magma then sends the two equal parts on their way in opposite directions, creating, thereby, a uniform pattern of "zebra stripes" marching off lock-step in chronologic order to an uncertain future in the maw of a subduction zone.

Usually, such stripes, as mapped, tend to a north-south alignment. Meyerhoff (1972) however, finds few areas where the magnetic anomalies are uniformly linear and symmetrical with respect to ocean crest. He postulates instead, that they are geologically old features possible formed in Archean time. This, of course, is mere *ad hoc* speculation.

Much of the literature reviewed on paleo-magnetism seems reasonable, founded on good data and scientifically acceptable research methods (Cox, Dalrymple, Doel, Mathews, Wilson, Vine, Sykes, Hess, Holmes, Matuyame, McKensie, and others).

Yet, all seem to skip blithely over a key component of the idea to explain how such bi-laterally symmetrical stripes can form on either side of a "spreading center" which in the case of offsetting transverse faulting requires that the "center" must move at exactly ½ the speed of the moving stripes if symmetry is to be maintained!. This uniformity violates virtually every geologic process one can find in the geologic record.

18.2 Early Map of Stripes in the N.W. Pacific Basin

The figure below is a map displaying magnetic anomalies in the N.E. Pacific published by Raff and Mason (1961). This map played a central role in the early work on ocean floor magnetics and in the ensuing controversy over the nature and meaning of the stripes as related to spreading. It also illustrates how the Devil may well be hidden in the details of the mechanisms that created the stripes.

Fig.18.2.1 Summary of the magnetic anomalies southwest of Vancouver Island. Areas of positive anomaly, assumed to represent normal magnetization of the underlying crust, are colored to match the radiometrically derived reversal time-scale for the past 4 million yrs., extended to 11 million yrs on the basis of a long magnetic profile spanning the Pacific-Antarctic Ridge. (From Raff and Mason 1961)

The mechanisms required to support the foregoing simplified statements about <u>how</u> spreading, symmetry, uniform spread rates, and straight lines occur, must include explanations to account for the following:

1) Variation in horizontal shear forces including, both compression and tension, would distort or destroy this apparent uniformity over extended time periods.

2) Uniform spreading at an opposing 180 degrees from single or multiple sources along a straight ridge crest, or by spreading from a zone generating crust by ---" a process of intrusion and extrusion of basaltic material, and by faulting, over a zone perhaps a few tens of kilometers in width." (Vine in Plate Tectonics 2001 p 64) — asks much of a natural physical process.

Magnetically tagged segments of crust must split equally and be sent in opposite directions from either side of a length of oceanic ridge ----a ridge characterized by a vertical conduit postulated to carry molten magma from a rising thermal convection cell elongated over distances of thousands of kilometers. The rising magma *cum* crust is then carried away with uncanny precision by sub-crustal currents moving in opposite directions at uniform velocity along a front measuring hundreds up to thousands of km. in length.

3) The "conveyer belt" streams transporting the new crust must be uniform on both sides of the ridge. They must be laterally extant parallel to the strike of the spreading center, and, the spreading velocity must be uniform throughout their length if the magnetic stripes are to remain parallel and maintain the nearly straight lines that appear to be repeated over hundreds of thousands to millions of years (e.g. Reykjannes Ridge) through a number of magnetic polarity reversals.

4) The length of these essentially straight magnetic stripes mapped south and west of Vancouver Island range from about 400 to nearly 650 kilometers. In other regions they are much longer with scarcely a break or an offset.

Added to the foregoing arguments that are evident from surface maps of magnetic stripes, and knowledge of geological processes, must be added a great lack of understanding in the physical processes that occur subsurface in the crestal areas of the major mid-ocean ridges world wide.

A substantial trove of knowledge has been gained in recent years from the study of continentally sited ophiolites. These rock suites, it is now believed, originated in oceanic crust near the interface between the base of the lithic oceanic crust and the top layer of the mantle
(Spooner and Fyfe 1973). Much has been learned from these ophiolite suites about temperatures, pressures, metamorphism, and the shearing and faulting processes that occurred during their growth. This knowledge would seem to be applicable to the development of ocean ridges, but, much remains unknown. Especially lacking is an understanding of the physical factors creating the ridges, the physical forces in the faulting regime, and the factors controlling emplacement and eruption of magma.

Fortunately, as a result of dredging, drilling, and manned submersible investigations a large number of oceanic sites have been identified and studied where ophiolite lithologies occur in crestal areas of mid-ocean ridges, trans-crestal fracture zones, and in transform faults.
(Nicolas, A., .1995, Auzende, J., et al 1989, Tisseau, & Tonnerre, 1993). This raises a number of questions (and doubts) about our present understanding of ridge creation, magnetic stripes and the validity of sea floor spreading.

18.3 Stripes in the North Atlantic

In the following figures depicting magnetic studies in the North Atlantic, Figure 18.3.2 shows magnetic stripes mapped almost “straight as a string” in the in the Atlantic south of Iceland. These anomalies march east and west of Reykjanes Ridge, a supposed spreading center.
(White, R.S 1999)

The lines are basically parallel, with only minor slightly curved deviations. Notably, from the Reykjanes Ridge to the margins of the North Atlantic Basin on both the North American and Euro-Asian plates, the magnetic stripes deviate less than (+) or (-) nine degrees from the straight line of Reykjanes Ridge. The entire pattern of essentially parallel stripes is oriented N33E, true.
With these constraints setting the stage, we are now forced to ask the following:

We know from measurement in recent decades and from prior geologic studies that the magnetic poles are not stationary but migrate slowly within historic time. (Navigators using compass directions must correct for declination and deviation. In high Latitudes, declination error increases and decreases depending upon Longitude) Navigational maps are dated for this very reason. This being the case, we come to a very basic question.

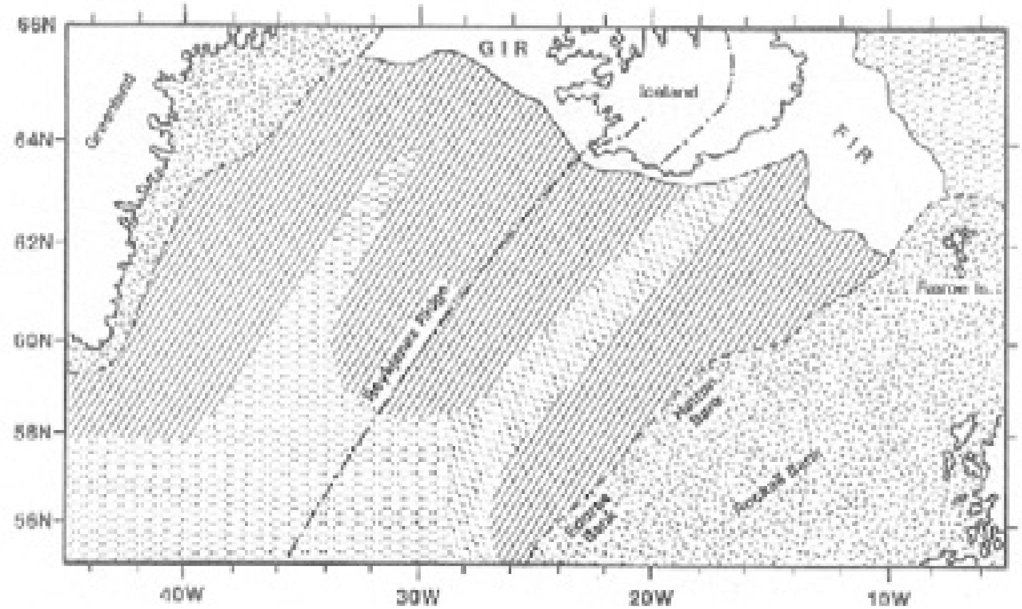
How can straight lines of parallel magnetic anomalies be generated repeatedly over millions of years if the (+), (-) polarity reversal of the poles occurs over geologically short time periods (as is generally assumed), while the north and south magnetic poles are wandering from a stationary geographical location, altering thereby, the earth's magnetic flux lines? The problem is further complicated by the exigencies of continental drift which would likely shift the position of the spreading center relative to a wandering magnetic pole, again displacing parallelism of the stripes relative to the axial spreading center.

After a reversal, we would in essence be taking a new "picture" of flux line orientation —and by extension— the orientation of magnetic anomalies. We would expect, therefore, in the higher north and south Latitudes , to find magnetic stripes of a given time period , and within a given belt of latitude to be: a) "smeared" or to have different orientations; and, b) to find a lack of parallelism over longer periods of geologic time in a grouping of anomaly lines in any extensive area. We could hardly expect them to appear as they do in Figure 18.3.2 centered on Reykjanes Ridge south of Iceland. Some possible answers to the basic question posed above may be:

a) Polarity reversals occur only when the magnetic poles are located at a predetermined fixed location.
b) The magnetic stripes do not represent chronologic time reversals.
c) The straight, parallel, consistently oriented magnetic anomalies cannot be the result of the earth's magnetic lines of flux.
d) The magnetic stripes are caused by means yet to be determined.

* * *

R. S. White



<u>Figure 18.3.1</u>

"Outline of the main tectonomagmatic areas discussed. Shaded areas in the northwest and southeast corners of the map represent stretched continental crust on the on the North American and Eurasian plates, respectively. Parallel shading shows crust devoid of fracture zones, and dotted shading is oceanic crust with fracture zones spreading orthogonally. Blank area is thick igneous crust above the Greenland-Iceland (GIR) and Faeroe-Iceland Ridge (FIR)." (White, 1999)

The above figure, taken from R.S. White (1999) poses some interesting problems.
a) How does one explain the absence of matching magnetic stripes on Iceland and areas to the east and west? b) How do we get "stretched" continental crust in juxtaposition to new crust "spreading" from the Mid-Atlantic Ridge. What is the timing?

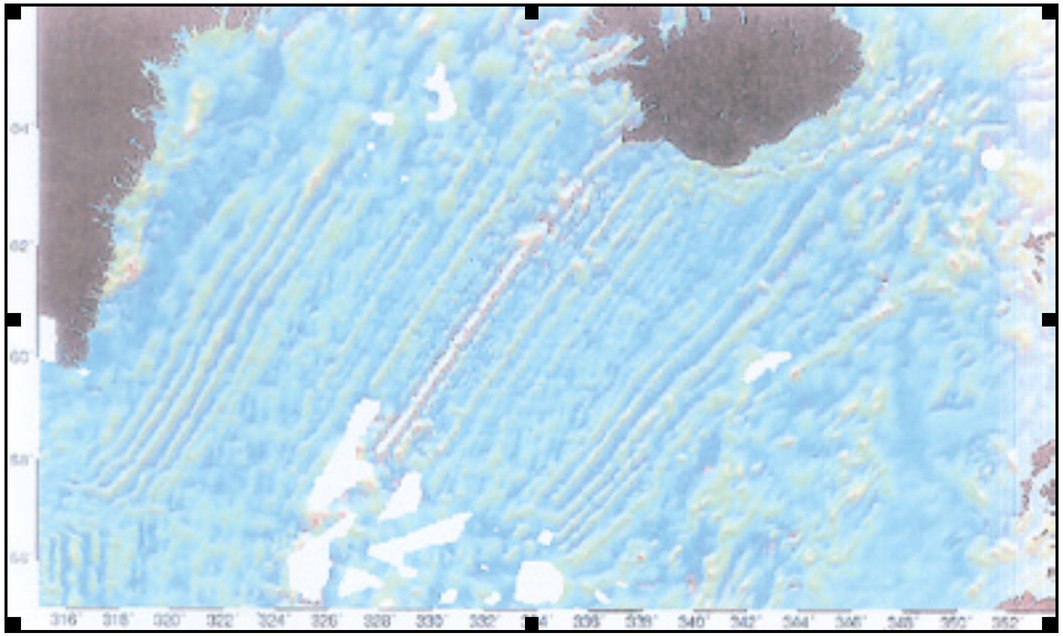


Figure 18.3.2

Magnetic Anomalies derived from a compilation by Macnab *et al* (1995).
(Taken from White,R. 1999)

Reykjanes Ridge- Iceland

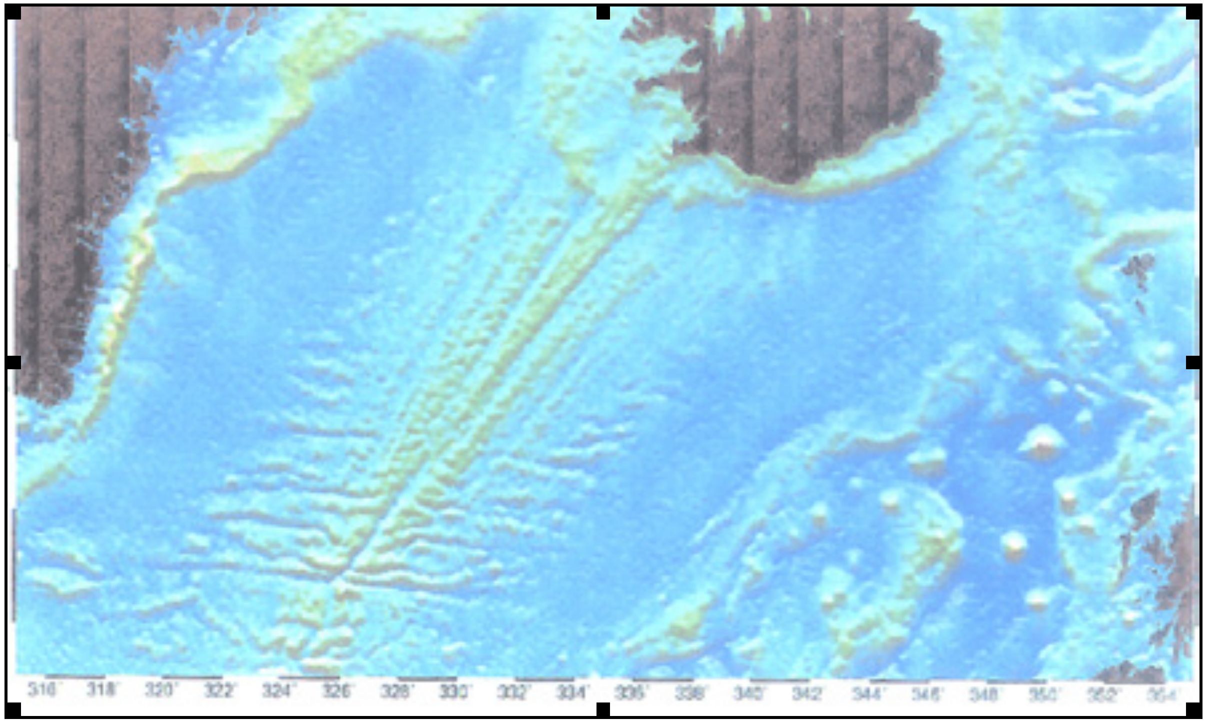


Figure 18.3.3

Free air Gravity Field derived from Geosat and ERS-1 satellite geoid data.
(Sandwell and Smith, 1995: version 7.2) (taken from White, R., 1999)

Reykjanes Ridge & North Atlantic

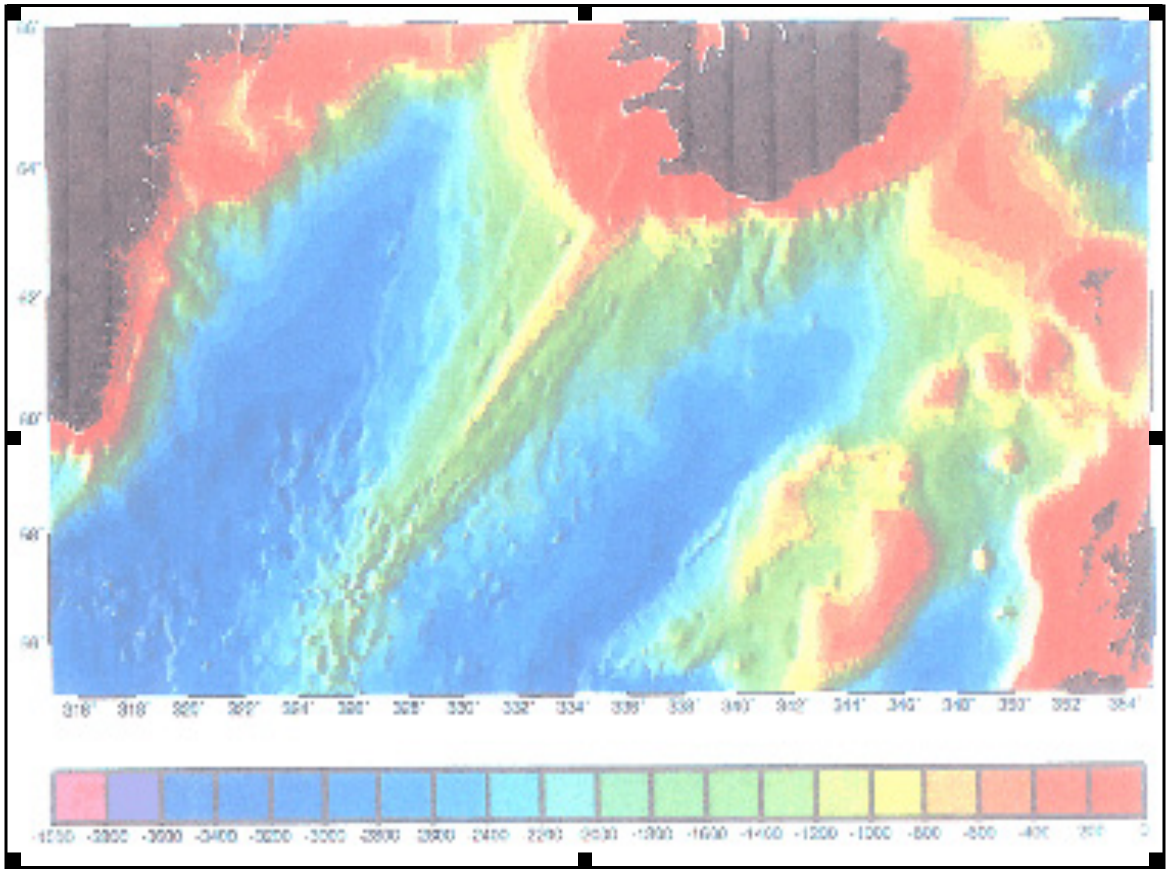


Figure 18.3.4

Bathymetry derived from five minute grid (National Geophysical Data Center 1993)

19.0 SUBDUCTION --- FACT OR FICTION?

19.1 Atlantic Ocean subduction Zones

Where are they? The Mid-Atlantic Ridge is a distinct geographic feature extending several thousand miles south from Iceland to the lower south Atlantic; then it swings easterly through
the south Atlantic into the Indian Ocean. (Ewing and Heezen 1956). This feature is, in fact, much larger and more extensive than the East Pacific Rise which is also claimed to be a "spreading center." There are no other similar features elsewhere in the Pacific.

Yet it is in the circum-Pacific rim where all the world's deep trenches are located. In the western Pacific are found the Kuril Trench, Mariana Trench and, the Philippine, Java, and Kermadec trenches. Fringing the north Pacific, the Aleutian Trench hugs the south flank of the Aleutian Island Arc for 2500 miles. In the southeastern Pacific, the Americas Trench and the Peru-Chilean trenches border the margins of Central and South America.

Plate tectonic theory attributes the creation of trenches to an on-going symbiotic relationship between trenches and oceanic spreading zones, wherein the care, feeding and maintenance of a trench is a function of its role as a dumping ground for the excess crust carried to it from a proliferative spreading zone. Logically, we should therefore, find some kind of quantitative or statistical balance between these two crustal features. Evidently, there is none.

The puny East Pacific Rise, much less developed than the Mid-Atlantic ridge, is deemed to be a spreading center driving Pacific crustal plates headlong under the fringing continental plates.
If convection currents and spreading centers power crustal "conveyer belts" to carry excess crust to subduction zones marked by deep trenches, trenches: 1) Why are there no trenches along the margins of the Atlantic? (excepting the Puerto Rico and Sandwich Trenches). 2) Where are the spreading centers that should be present to drive the conveyer belts predicted to carry crust to the multiple trenches in the western and northern Pacific? None have been mapped and identified as such to date. Can it be that the presently accepted hypothesis is wrong and that other processes are at work?

The Atlantic Mid-Ocean Ridge is cited as a prime example of a spreading center. This function is highly questionable, either presently or in the past.

An excellent review of past work (beginning in the 1800s) on the origin and structure of the Atlantic Ridge by many distinguished authors is given by A. Meyerhoff (1992). Because of limited seismic technology then existing and scattered data until about the 1980s, many hypotheses relating to the origin and structure were proposed.

Among these is the concept that the ridge is a spreading center created by thermal convection. Convection and spreading are, of course, concepts vital to the theory of Plate Tectonics. Around the 1970s, reflection seismic profiles (both single channel and multi-channel CDP) began to reveal more detail about the internal and flanking structures of the ridge (Rabinowit, P. et al 1978, and Rona, P.A 1980). These profiles strongly hinted that reverse faults and thrust faults are present.
Subsequently, Antipov, M.P., et al (1990), utilizing enhanced CDP profiles, published

interpretations illustrating a broad zone of reverse and thrust faulting 300-400 Km wide with a N-S extension of not less than 1000Km on the western flank of the Ridge between 13 and 14 deg. N. Lat. This of course, is indicative of compressional stress—not tensional stress —as predicted for a "spreading zone."

The case for compression is further supported by widespread bore-hole measurements published by N. Hast (1969) based on extensive uniform stress patterns prevalent in Fennoscandia and from Spitsbergen in the north to Zambia in the south. Hast concludes:

> "These measurements indicate that the horizontal stress field may belong to a general stress system according to which large parts of the Earth's crust are stressed. Measurements performed in the Atlantic area coastal zones, on Iceland and other islands seem to show that the Atlantic floor behaves as a rigid plate stressed by horizontal compressive and shear forces, in all probability, emanating from the zone of contact between ocean floor and continental crust."

The age of rocks found along the North Atlantic Ridge further places in question its genesis as a tensional spreading center. Meyerhoff, et al (1992) report that within an area bounded by 37 N Lat to 45-30' N. Lat. and 19 W Long to 35 W Long. (greater than 800,000sq. KM.), thousands of outcrops of Proterozoic and Paleozoic rocks appear to be present. This conclusion is based on the fact that nearly every dredge haul from the uplifted blocks on the Ridge contain old rocks—many of them granitic. Are all of these merely ice rafted?

As far north as 48 N Lat., Aumento and Loncarevic (1969) report similar findings. Dredge hauls from the Bald Mtn. Region at 45 N Lat. consistently recovered silicic rocks (74%), including metamorphics dated Proterozoic ranging from 1550 to 1690 Ma (Wanless et al 1968).

Rocks older than Jurassic are also found along the Ridge near the equator on the flanks of St. Peter and St.Paul Islands and near Ascension Island further southeast.

Meyerhoff et al (1992) conclude that, "The Mid-Atlantic Ridge is at least as old as early Paleozoic, and is probably much older."

19.2 Volcanic Chains and Oceanic Trenches   Rev 1-20-04

It is believed that gravity is the operational factor along mega-reverse faults delimiting oceanic and continental blocks related to oceanic trenches. This is due to motions initiated by the shifting of deep dense mantle materials that cause differential movement between continental margins and oceanic blocks in response to increasing gravity. (Sec.13.0-- Gravity and Epeirogeny). This may also provide a mechanism to explain the creation chains of volcanic peaks and volcanic archipelagoes set back from the surface traces of these mega- faults by distances of roughly 120 - 150 km.

Consider that while both oceanic and continental blocks are subjected to slowly increasing net (g), and thus to increasing weight dictated by density, the oceanic block being thinner but underlain by dense mantle, will tend to subside more than the continental block due to isostatic factors as mantle shifts from beneath the oceanic block to a location under the continental block.

Thus, over a period of time, the continental block will tend to either maintain its elevation or to actually gain in elevation, while at the same time being in a state of compression and being under-thrust by oceanic mantle.

The net result, however, will be that the margin of the continental block, which is generally conceded to be thicker than the oceanic block, now presents a relatively thin and weaker triangular wedge at the margin of the hanging wall due to the 20 to 45 degree fault plane below.
(Fig.19.3.1)

Because of mutual contact at the fault, and under conditions of compression, this upper continental lip is partly supported at upper levels by the under-thrusting oceanic plate. However, because of isostatic disparity, vertical movements between the two blocks eventually places tensional strains on the hanging wall lip. This creates nearly vertical faults in the continental block which connect deep magma sources in the mantle to the surface. These vertical faults can then become feeders to create volcanic activity at the surface forming peaks and archipelagic islands.

By projecting the traces of these mega-faults to depth they will be seen to underlie the general locations of ubiquitous volcanic peaks which are commonly found in close relationship to trenches and continental margins around much of the Pacific basin---- thus giving rise to the appellation, “Ring of Fire.”

The persistent relationship of volcanism in chains of peaks commonly situated within distances of 90- to 200 km from oceanic trenches around the Pacific has frequently been mentioned in the literature and depicted in diagrams. Nearly all depict magma chambers supplied from depth, which feed surface volcanism within a limited range of distances landward from trenches. None are found sea-ward of the trenches.

These magma chambers, it is said, work their way diapirically to the surface from vaguely described sources of frictionally induced melting----somehow delivering their molten and gaseous cargoes to eruptive locations with uncommon regularity in a relatively uniform range of distances landward from the trench.(Fig. 19.3.2)
Surprisingly, it appears that no one has previously suggested an alternative explanation of the Pacific “Ring of Fire” in the context of gravitationally controlled epeirogenic movements.

*   *

Island arc

Tholeiite series

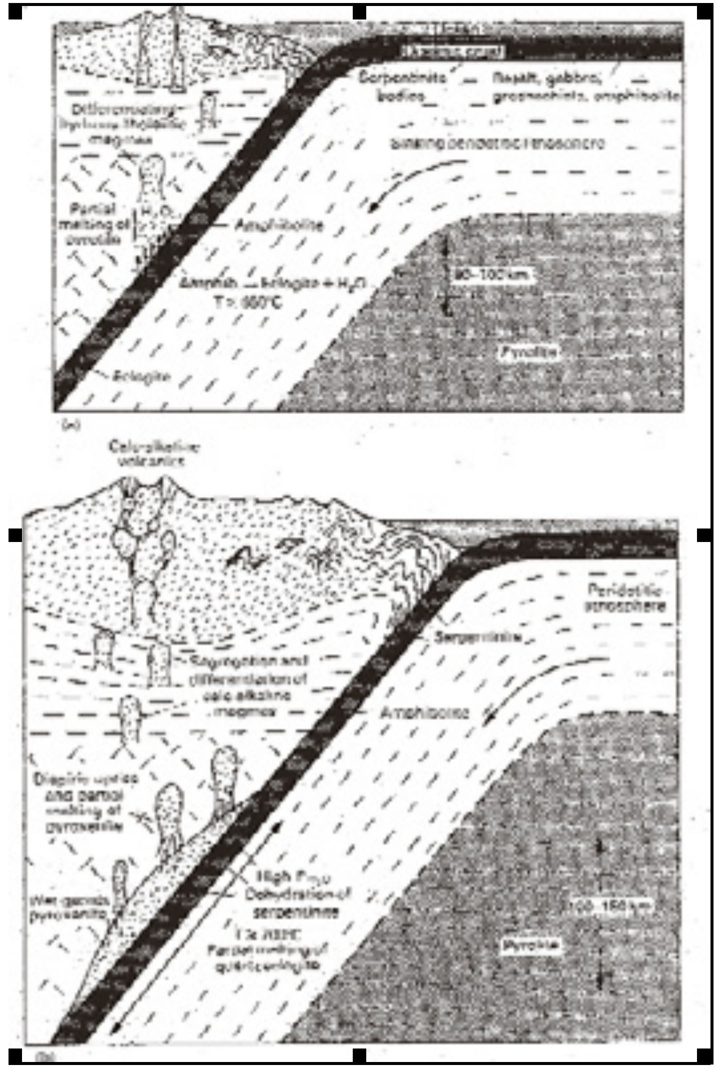


Figure 19.3.2

(a) Early phase of development of an island arc; (b) later phase of island arc development (redrawn from Ringwood, 1974, in Journal of the Geological Society of London, 1974

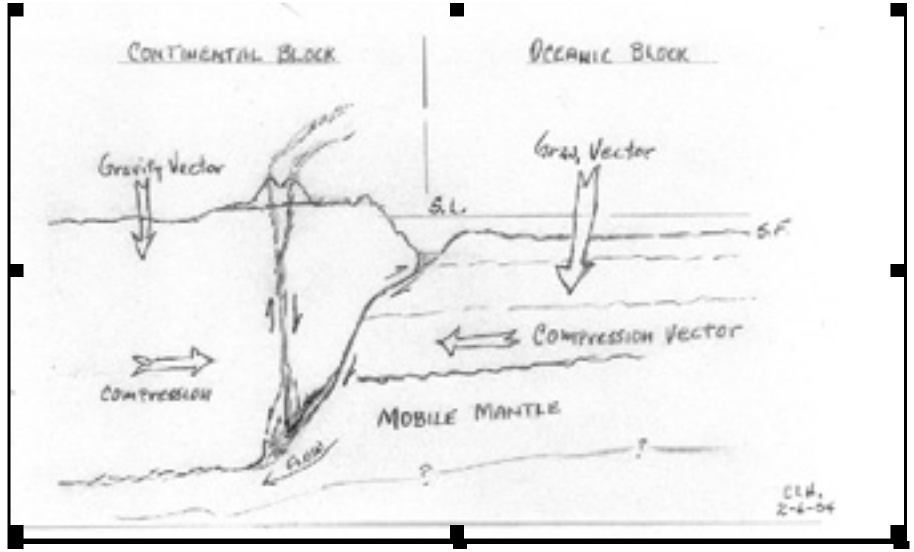


Figure 19.3.1

Here is a possible mechanism to explain chains of volcanos set back from trenches at relatively uniform distances from the deep trenches encircling the Pacific Basin.

A) Increasing gravity upsets the isostatic balance between adjacent oceanic and continental blocks.
B) compression maintains contact between the blocks along a mega-fault
C) Both blocks tend to subside with increasing gravity
D) the more dense oceanic block subsides most
E) mobile mantle flows beneath the continental margin in compensation
F) continental block ceases to sink then stabilizes getting some support from the oceanic block along the fault zone.
G) mantle flow continues
H) isostatic process allows further sinking of oceanic block and possible rise of continental block.
I) tension strain on the hanging wall lip (now with reduced support) allows vertical fault ruptures about 90-150 km landward from the surface trace of the trench.
J) magma or melt from the mantle works upward along the tension faults to form volcanic peaks and/or islands along an archipelago.

19.4 Subduction and Trenches: Clues Provided by Earthquakes

Diagrammatic illustrations of subduction invariably show a sharp flexure in oceanic crust at the point where the subducting plate supposedly "dives down" under a continental margin. This departure from the surface is regarded as the *cause* of deep ocean trenches.
The crustal slab is depicted as sliding downward at an angle of 20 to 30 degrees, then increasing in angle to about 60 degrees and continuing down until it melts and is resorbed into the molten or plastic mantle at depths of 500 to 700 Kilometers—the calculated depth for the foci of some earthquakes. This is a simple and eminently understandable model. There are, however, troubling questions posed by this neat model.

The oceanic crust is postulated by most authors to be generally weak, brittle, and perhaps no more than 30 km to 70 Km in thickness. Based on refraction seismic studies, some authors estimate the average thickness of lithified oceanic crust at only 5 to 7 Km (Belussov,V. 1962 , Stacy, F. 1996, and others) If true, its brittle weakness could , perhaps, readily succumb to the suggested bending. But, if this occurs, and further weakness is induced by fracturing, how can the slab maintain structural integrity while sinking and being thrust downward to depths of 500 to 700 Km even if the thickness were at the upper estimated limit of 70 Km? (43 Mi.)

Additional weakness and reduction in density would be induced by heating so that as the process continued, the slab would become analogous to a wet noodle being pushed into bread dough. But, in this case the noodle would likely have been broken into disparate segments. This raises another troubling problem----earthquakes.

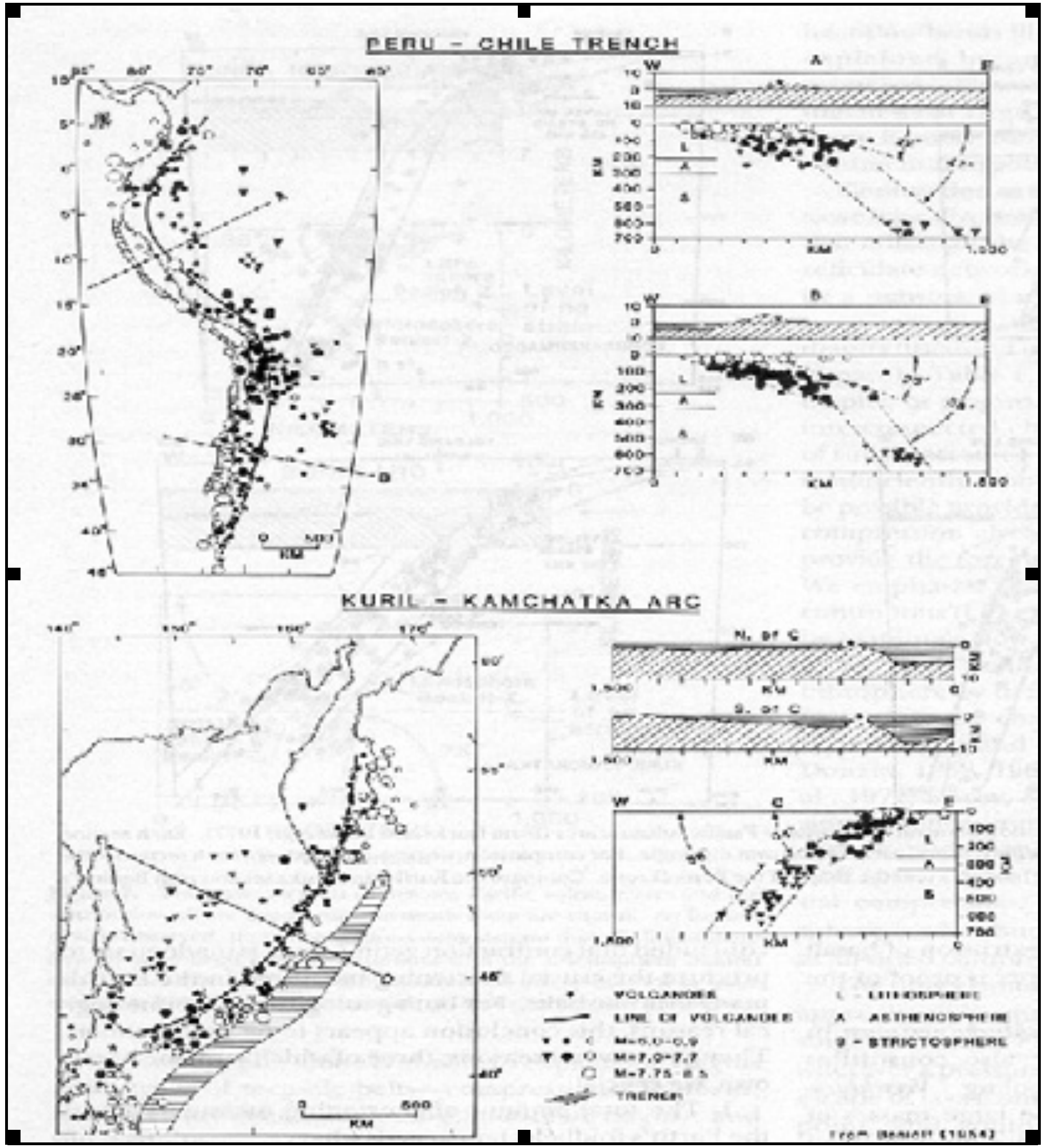
The focus of earthquakes at supposed subduction zones have been found to plot along the projected contact of the "subducting" plate with the margin of the continental plate. This inclined zone of quake foci has been named, the Benioff Zone (Benioff, H. 1954), later called the Wadati-Benioff Zone.

The plots of these foci angle downward and away from the postulated point of initial subduction (at the trench edge). They then plot toward and under the continental plate. (Figs. 19.4.1 &19.4.2) Relatively few quake foci occur within the trenches and even fewer are located ocean-ward of the trenches. This seems most unusual since a large measure of crustal flexing, faulting, and fracturing would be expected to occur where the first deformation is initiated. Proponents of subduction will argue that the earthquake foci mark locations of shear stress between the upper plate and the top of the subducting plate. However, the same would be true for stress conditions induced by compression along a mega- thrust fault.

Walzer, U. (1990) observed:

> "Seismicity shows a distinct maximum (in a "subducting" slab zone) between 500-700 km and suddenly disappears below 700km."

If tensional break-up is proposed as causing these deep quakes, why are there so few plotted quakes resulting from tensional stress release due to flexing in shallow depths at the trench areas?
Moreover, it should be pointed out that the flexing of a crustal slab 30 to 70 Km (or even 5-7km)



<u>Figure 19.4.1</u>

Sections across the Peru-Chile Trench and the Kuril Volcanic Arc, showing distribution of Hypocenters. Originally published with permission of the *Geological Society of America. (*Reproduced from *New Concepts in Global Tectonics* 1992, Meyerhoff et al)

NEW HEBRIDES & TONGA - KERMADEC TRENCHES
MARIANAS & KURIL - KAMCHATKA TRENCHES

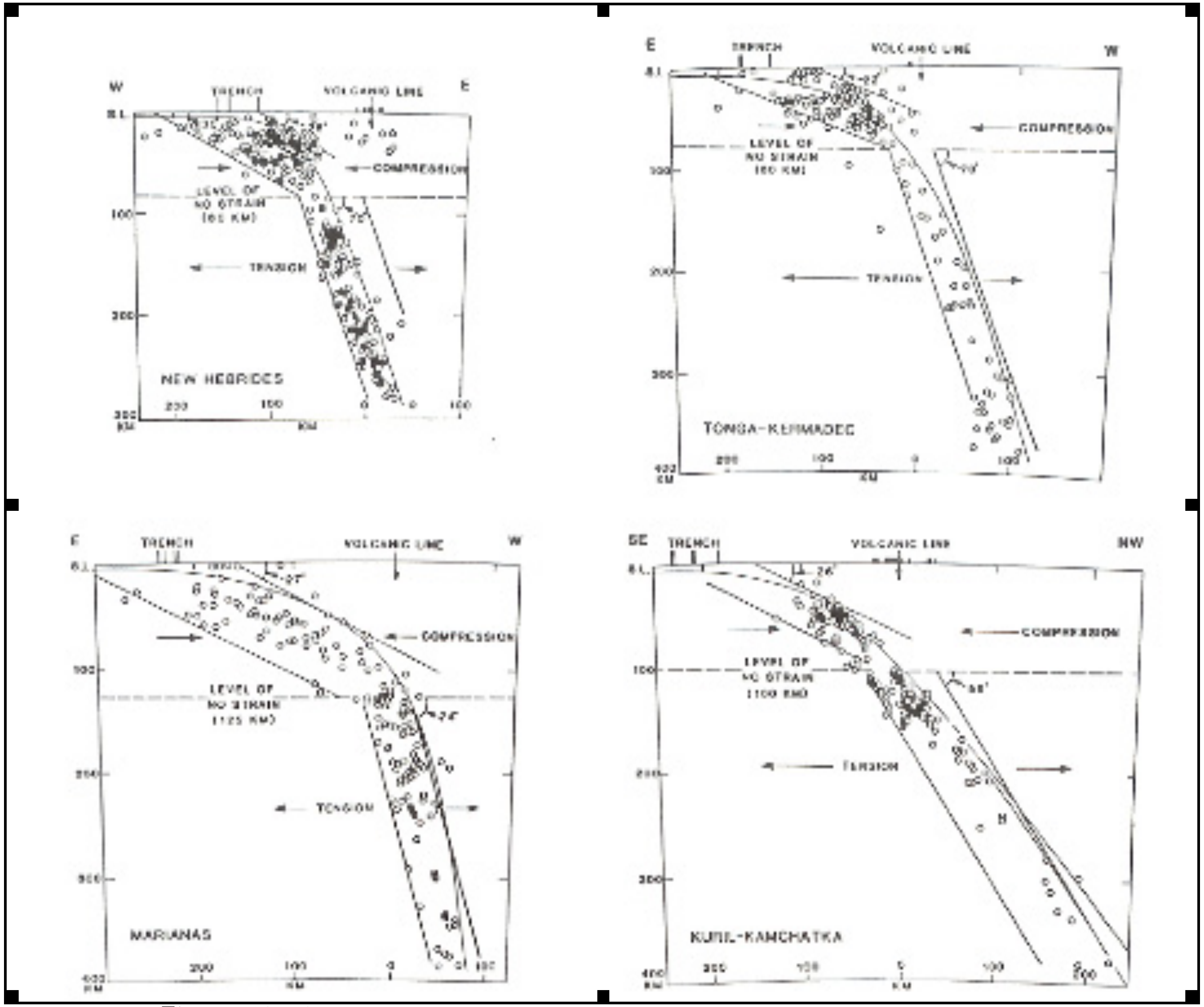


Figure 19.4.2
Sections showing hypocenter distribution beneath four western Pacific Volcanic arcs (from Isacks and Barazangi, 1977). Each section displays distinct lithosphere and strictosphere Benioff zones, each with its own dip angle. For comparison ----the curved line drawn by Isacks and Barazangi (1977) to repesent the shape of the Benioff zone has been retained. (Reproduced from New Concepts in Global Tectonics 1992, Meyerhoff et al)

In viewing these sections, one must ask what kind of mechanism can produce compression in shallower horizons and tension in deep horizons? An alternative to Plate Tectonics' spreading and convection is given in Sections 19.2 -19.3 and illustrated in Figure 13.0.1

in thickness would generate not only tension in it's upper reaches, but, also compression and shear stresses in it's lower zones.

One is, therefore, constrained to ask the following:

> 1) If the postulated flexure of oceanic crust at trench edges where the crust starts to "dive under" another lithic plate does not produce quakes either by tension or compressional stress where quakes should occur, are we then entitled to question the model?. Or, may we, in fact, question the validity of subduction in its entirety?"
>
> 2) Is there another model or mechanism that better fits the locations and depths of quake foci observed near oceanic trenches?

Benioff (1949, 1954) suggested that trenches mark the location of, "Great faults extending to 650 km in depth and 450 km in length." This author generally agrees.

19.5 Earthquakes Along Trenches

Wadati, (1935) discussed the "double-layered" structure of earthquake epicenters and foci in the Wadati-Benioff zone. Benioff (1954) presents maps, and cross-sections showing the locations and depths of earthquake foci and volcanic zones in relation to the orogenic faults and the principal trenches which circumscribe the Pacific Basin. Hasagawa, et. al., (1978) depicts this layered phenomenon in cross sections. Uyeda (1981) reports the mechanism in the upper layer as characteristic of "down-dip compression" and in the lower layer characteristic of "down-dip tension." Uyeda, however, has difficulty in understanding this paradoxical situation, and other features, in terms of the commonly accepted model of subduction zone theory, pointing out that, "the amount of energy to produce the enormous thermal energy under the young back-arc basins is orders of magnitude greater than the potential energy available from subduction from a high density (oceanic) slab" (Atrtyushkov, 1981).

19.6 Critical Commentary on Subduction

The Great Oyashiio Paleoland

In a paper on the Oyashiio Paleoland, an area in the northwest Pacific Ocean, D.R.Choi (1987) and Choi, Vasi'yev & Tuezov, (1990) show that the crust in this area is not comprised of typical Mesozoic or younger basaltic materials, but instead, is composed of Archean, Proterozoic, and Paleozoic continental crust. This is confirmed by migrated multi-channel seismic sections across the Japan-Kuril-Kamchatka trench and is further supported by dated samples from dredging, DSDP drill sites, and correlation with lithology on-shore.

Thus, continental rocks occur on both flanks of the Japan-Kuril trench and apparently underlie a substantial area of the sea-floor to the east within an area roughly enclosed by 160 W Long and 30 N Latitude. Choi et.al.(1990) have interpreted seismic sections to show this suite of old continental rocks is present on both sides of the trench and is continuous beneath it in at least one area surveyed.. (Choi et al. 1990)

> "Despite the general acceptance of Plate Tectonics, neither factual evidence nor convincing mechanisms as to how the movement and subduction along the trenches

of crustal plates in the Western Pacific takes place has been published. Yet this region is one of the most critical areas in the Plate Tectonic hypothesis."

On the landward western slope of the Japanese trench, the DSDP drilling program (56^{th} & 57^{th} cruises) reported evidence indicating subsidence ranging from two to six Kilometers. (Resanov, I.A. 1978)
If subduction trenches are fed oceanic crust from the ocean side of a trench, postulated by Plate Tectonics hypothesis, why should the landward side of this trench be sinking when theory says it should be rising?

Menard, (1972) made the following observation:

> "The sides of an oceanic trench move together at more than 5 Cm per year, and it Would seem that the sediment sliding into the bottom of the trench would be folded into pronounced ridges and valleys. Yet, virtually undeformed sediments have been mapped in trenches by D.W. Scholl and his colleges at the U.S. Navy Electronic Lab. Furthermore, the enormous quantity of deep ocean sediment that has presumably been swept up to the margins of trenches cannot be detected on the sub-bottom profiling records."

Note that none of the crustal shear zones in the eastern Pacific headed toward trenches along Central and South America at nearly 90 degrees appear to disturb the seaward wall of the trenches. At Cape Mendocino. (Calif.) no trench is present, but the Mendocino fracture zone appears to offset the down-dropped plate west of the continental scarp.

One might expect that because of disparate rates of relative movement in parallel belts between fracture zones, as calculated for crustal motion based on magnetic striping, this would be reflected as offsets in the outer walls of trenches. Apparently this is not the case.

19.7 Some Common Features of Oceanic Trenches

Fisher and Revelle (1955) listed common features of Pacific trenches:

* Trenches are generally "V" shaped in cross-section, though some with sediment fills are slightly flattened at bottom. (see Fig. 19.7.1 from Fisher and Revelle, 1955)

* The Japan and Philippine trenches have parts with flat bottoms in the range of two to ten miles wide (3.2 to 16.0 Km).

* Zones of the Earth's most intense earthquake activity occur under and beyond the landward wall of the trenches.

* Trenches display a deficiency of gravity.
* Isostatic equilibrium does exist near trenches.

2) The seaward margins of the trenches invariably lie at relatively lower sub-sea elevations, averaging in a range of 4 to 6 Km depth (Hayes & Ewing, 1970)
3) In a number of instances, trench margins on the seaward side have lips, narrow shelves or low ridges that are slightly elevated compared to the sea-floor more distant from the trench. If trenches form because "cold dense" oceanic crust sinks to form the trench, why does an elevated lip form along the seaward wall? (Fig. 19.7.1)

4) Where trenches are arcuate, they tend to be convex outward on the landward side and concave on the seaward side.

If we accept or postulate that the difference in elevation of the blocks of crust bounding the trench is a function of the physical factors of the blocks and that they are essentially in isostatic equilibrium because of these factors, we must draw certain conclusions:

a) The more elevated (landward) block must be less dense, thicker or both, than the seaward block.

b) Under isostatic conditions the seaward block must be more dense, thinner, or both, compared to its opposite. Materials beneath a thinner oceanic crust, if relatively more dense, would also result in isostatic elevation differential.

It is hard, also, to understand how compressional mountain belts form on the continental side of deep trenches when it is postulated that the trenches are "subduction zones." Where relatively thin layers of basaltic crust plunge (due to their density) down steeply dipping Benioff zones, creating on the way, deep focus earthquakes at depths as deep as 700 km.

If oceanic plates entering the trench subside because they are cold and more dense, other questions arise:

1) How does this "cold" oceanic crust in a density range of 3.0 to 3.1 displace plastic or liquid mantle of greater density at depths in a range of 300 to 700 km.?

2) How does this sinking crust whose dominant force vector is downward, impose sufficient horizontal force to create folded mountain belts set back from the trench 80 to 100 miles or more, and dotted at regular intervals with volcanoes? (The Pacific "ring of fire")

3) How are linear sub-sea ridges, unrelated to any evident trench, created in this scheme of things? Why are mid-ocean ridges not more abundant, especially in the Pacific Basin where trenches circumscribe much of the basin? These are trenches said by "Mobilists" to require care and feeding by spreading centers. Why, if controlled by thermal convection in the mantle, are "spreading centers" not oriented randomly? Where is the spreading center maintaining the 2600 mile long Aleutian trench?

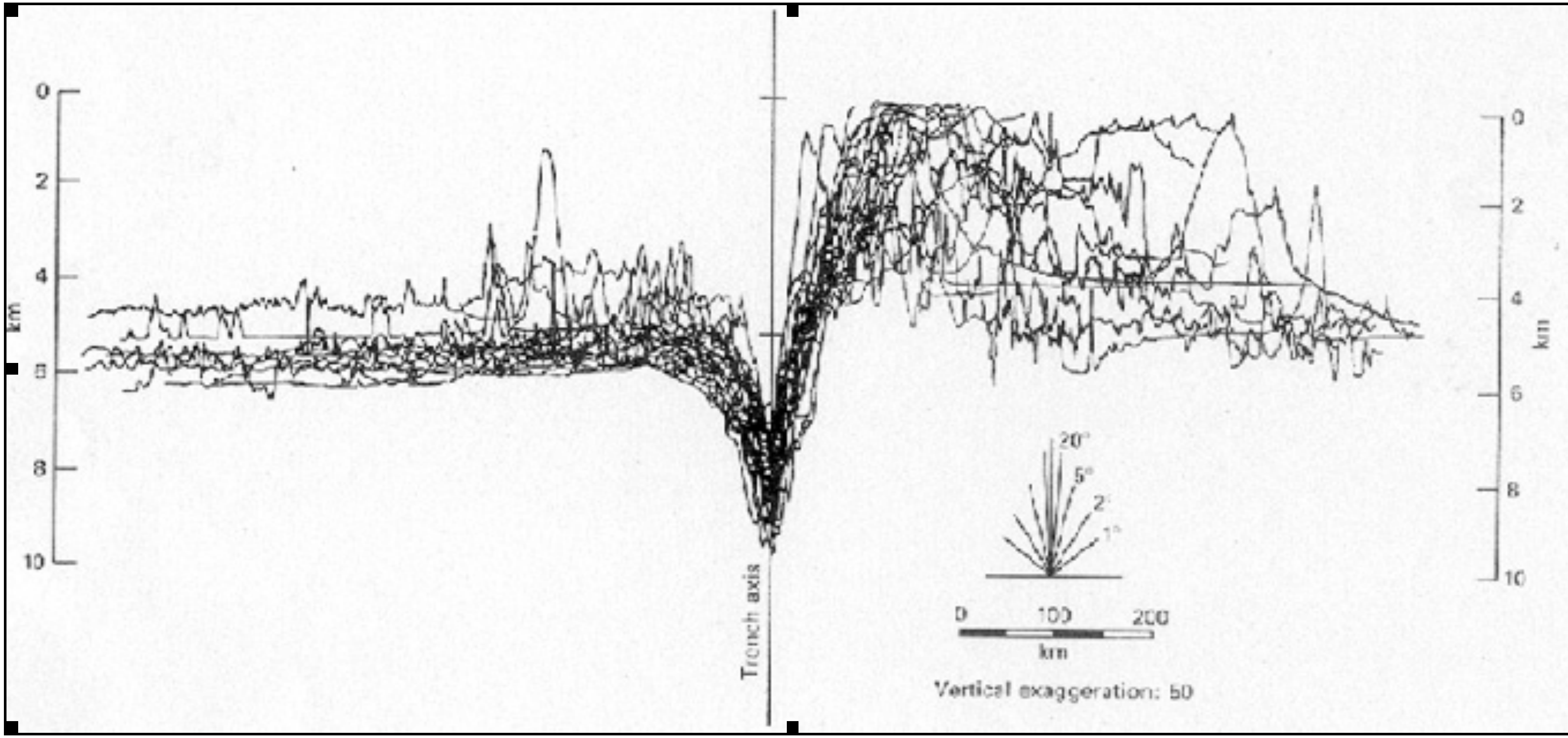


Figure 19.7.1
Stack of 35 projected topographic profiles of Pacific "subduction" zones from Fisher and Revelle (1965) (Redrawn from Hayes and Ewing , 1970 with permission from John Wiley)

* Heat flow near the floor of the Acapulco Trench is less than ½ average for the Earth's surface.

* The deepest trenches contain virtually no sedimentary fill.

19.8 Pelagic Sediments and Subduction

Pelagic sediments have distinctive characteristics (Menard, 1964); they are quite unlike near-shore terrestrial turbidity deposits. Generally, they consist of clays, and calcareous or siliceous organic oozes, derived mostly from microscopic pelagic life forms such as foraminifera and diatoms, but also including volcanic ash, dust, and suspended continental sediments.

Pelagic sedimentary materials accumulate slowly at rates in the range of 1 to 10 mm per thousand years. Many factors influence the rate of pelagic sedimentation as demonstrated by "more than 2000 cores of the deep-sea floor in the Atlantic and Pacific where a large number demonstrate discontinuous sedimentation" (Menard, op cit).

Menard and others (Revelle 1944, Kuenen1950, Arrhenius 1952, Bradshaw 1959, Bramblette 1961) point out that pelagic sedimentation is controlled by a complex interplay of many factors.

These include air and ocean currents, water depth and temperature, benthic organism populations and proximity to continents. Non-the-less, pelagic sediments possess characteristics which readily identify them as distinct from turbidites and other materials derived from terrestrial erosion.

Manganese nodules are unique to pelagic deposits. These have commonly been collected at abyssal depths of about 4500 to 5000 meters, but, are found less frequently at both shallower and greater depths. This black sooty material consists dominantly of manganese and iron oxides with lesser amounts of Cu, Co, Ni, and trace amounts of other metallic elements. The mode of occurrence includes coatings, crusts, micro-nodules, slabs, and rounded nodular forms several centimeters in dimension.

A most important factor is their extremely slow rate of accumulation. Probable rates lie in the range of 0.1 to 0.01 millimeter per 1000 yrs. (Menard op.cit. p175). This is far less than the average rate of accumulation for "normal" pelagic sedimentation such as clays, silicic and calcareous oozes estimated at > 1.0 mm/1000 yrs.

Since early photos showed these ferro-manganese nodules on the sea-floor surface, there was a question of whether the nodules might be buried and incorporated in older deeper sedimentary layers. Subsequent studies gave an answer (Menard op.cit).

> "The cumulative evidence of dredges, cores, and cameras is that nodules are abundant below the sediment surface as well as on it."

This Mn-Fe nodule identification *tag,* coupled with the unique qualities of pelagic sedimentation overall, is extremely important to the Plate Tectonic subduction hypothesis.

Text book diagrams and lecture slides illustrating subduction and trench formation invariably depict an encroaching oceanic plate diving downward along the Bennioff-Wadati zone
beneath the landward margin of a trench. In this process (the text or lecturer explains) oceanic sediments are “scraped off” the descending plate to accumulate at the front of, or on the underside of, the landward “hanging wall.”

We may now ask; if this subduction process has been in action for tens of millions of years (or longer) where has been found evidence of accumulated pelagic sediments scraped from oceanic plates in their slow dive to oblivion?

Surely, somewhere in the world, along continental margins, evidence of pelagic sediments derived from this process would be preserved. The Chilean Andes where Darwin climbed to elevations above 12,000 feet in the 1890s and found (Tertiary ??) marine fossils would, it seems, be a promising locality to search for such unique “scrapings”----. Yet, this author has found no published literature indicative of pelagic materials in that locality or elsewhere.

19.9 Where is the Evidence of Subduction?

Oceanic trenches have come to be accepted as *evidence* of subduction, a mechanism also cited to *cause* trench formation. Subduction has also been used to explain the occurrence of compressional and tensional earthquakes in the upper and lower zones along and below the presumed glide plane of the subsiding plate. Even so, this still leaves other factors unexplained or difficult to understand. Uyeda (1981) discusses these problems suggesting that, “all subduction zones are by no means the same” and that other models may be involved.

After initially expressing doubts as to the validity of some aspects of subduction, he concludes that subduction is “not the only agent that engineers the complex situation in the trench-arc-back arc systems.” He goes on to analyze and classify the major Pacific Rim trenches into three distinct types and to explain discrepancies in those cases which do not fit the proposed models.

The difficulty Uyeda and other authors face in the task of analyzing deep ocean trenches is that most of them are shackled to the idea that trenches are indicative of, and are created by, the mechanism of subduction, a concept that in large measure is simply not true. More to the point, it is false! How is it possible to understand and explain discrepancies that do not fit the model when the model (and the mechanism) is wrong and the facts that do not fit must be stretched and made to fit by speculative *ad hoc* processes.

Certain physical relationships related to oceanic trenches appear to be common, if not ubiquitous:

1) The elevated block, invariably on the landward side, is characteristically populated by an arcuate or semi-arcuate archipelago of volcanoes, volcanic islands, and islands of mixed lithology, or at least shoal areas. Some of these landward areas are, of course, continents. Benioff (1954), Gutenberg and Richter (1954)

4) Why are convection cells (if they cause mid-ocean ridges) oriented mostly north-south?
Why are convection cells narrow and elongated instead of rounded or lacking in directional orientation? Where are the trenches formed by "spreading" from the "type specimen" of spreading centers —the Mid-Atlantic Ridge?

These are hard questions, for which Plate Tectonics hypothesis offers no answers. It is clear that the truth must be sought elsewhere.

19.10 The Mechanism of Trench Formation

The forces acting on contiguous oceanic and continental blocks in an environment created as the Earth slows in rotation will be as follows:

1) Net gravity slowly increases as centrifugal force diminishes. The result is that the weight of both blocks (wt = mg) will increase, but not equally. In the less dense landward block (2.7), weight will increase less than in an equal unit volume of the more dense seaward block (3.0-3.1). By isostatic principles, the seaward block will sink more than the landward block. Therefore, the line of contact between these two blocks standing in near equilibrium at a given point in time will tend to adjust vertically relative to each other as the value of gravity changes. This situation along a line of contact, creates a "never healing wound."

2) Compressional stress is generated, maintained, and increased, as *eustatic gravity* slowly increases and reduces Earth's total surface area. We now have two crustal blocks with different densities and thicknesses standing in juxtaposition along a "never healing" fault zone where both blocks are being subjected to compressional stress, and where opposing force vectors can be thought of as concentrating along their line of contact(s) within the fault zone.

3) Over a period of geologic time, the isostatic disequilibrium of increasing net (g), and increasing stress of compression will seek relief by forcing the blocks together along what amounts to a gigantic high angle reverse fault (Benioff 1954)---- i.e. the 'Benioff-Wadati zone.' At the same time the landward block will be elevated; and the seaward block will subside.

4) Due to the heterogeneity of crustal materials and their differences in mechanical strength, compressional yielding, parallel to the fault, at varied distances along the line of contact may induce nominal strike slip movements.

5) Major sinking in the range of 1000 to 5000 meters over large areas of ocean floor in all the world's oceans since middle Cretaceous strongly supports the mechanisms outlined in

item numbers 1 through 4, above. To review ocean basin sinking see:
(Hess 1946), (Hamilton 1956 & '57), (Ladd and Tracey 1957), (Gibson, 1960), (Menard 1964), (Resanov 1978), (Smith, D. 1985), and (Van Waasberg1993)

19.11 <u>Conclusions:</u>

< A slow increase in gravity due to constant reduction in the Earth's rate of rotation is the prime mover in tectonism.

< As gravity increases, ocean basins subside and continental sections may subside, rise, or remain stable due to differences in the average density of their crustal components. Continents are subject to on-going reduction in average elevation by erosion (which increases with altitude), tending thereby to limit their heights. Ocean basins have no similar erosional limit on subsidence (there are others) tending to become deeper over geologic time.

< Compression is the dominant continuing force in the crust. Due to mechanical heterogeneity in the crust and perhaps due to lateral forces exerted by the moon pulling in a westerly direction on the Earth's tidal bulge (a possible element in continental drift), it is probable that from time to time in geologic history, there have been periods when localized crustal tension co-existed with compression.

< Oceanic trenches are created by differential vertical movement between continental crustal blocks and oceanic crustal blocks. The continental crust tends, over time, to rise while oceanic crust tends always to subside. Both elements of the crust meet in contact under conditions of horizontal compression, tempered at times in some trenches by short episodes of local
Tension and at other times by probable lateral strike-slip movements. The latter, due to irregularities in the (plate) contacts, cause local extension and depression analogous to "sag ponds" found along strike slip faults on land, but on a far grander scale due to the thickness and massive size of discordant plates. These mechanisms coupled with the differential vertical movements between the oceanic and continental blocks along a compressional crush zone of mega-faulting, create the deep ocean trenches.

< The major crustal breaks related to trenches are in essence reverse faults or thrust faults
Benioff (1954) wherein the continental (landward) block moves upward and the oceanic block downward over extended periods of geologic time. In shallow zones the angle of the fault planes of these orogenic mega-faults may have an inclination of 30 degrees or less in shallow zones to 300 km depth as is believed to be the case in the Japan Trench (Uyeda 1981).

< Benioff (1954) published a table giving dips based on earthquake foci averaging 33 deg. in the

depth range of 70-300 Km but becoming steeper to an average of 60 deg. in the depth range of 300-700 Km. These figures are based on study of five of eight major circum-pacific trench zones.

The distinction between the concept of reverse faulting versus a subduction zone concept is that the driving mechanism is compression generated by a reduction in the earth's surface area, and ocean floor subsidence. It is not a mechanism born of an expanding oceanic crust, or a cooling and densification of that crust, followed by a diving or sinking of the plate margin into the mantle at its contact with continental materials. The latter is speculative hypothesis unsupported by good physics or good geologic evidence.

< The "need" for subduction as an element of plate tectonics will be eliminated when "ocean spreading" too, is rejected as a faulty hypothesis. Much evidence (i.e. Proterozoic and Paleozoic rocks in the oceanic crust) is now accumulating to disprove spreading in areas previously cited as typical of the ocean ridge spreading hypothesis. (e.g. the northern Atlantic, central Atlantic, and the northwest Pacific (Choi 1987,1990). See also studies of mantle rock exposures within and near oceanic ridge segments cited in Tables 17.4A, B, &C in this publication. (Tisseau and Tonnerre 1993)

* * * *

20.2 What is Needed Continental Drift (Note)

Nearly all deep DSDP holes drilled have terminated upon reaching basalt or “basement” below easily penetrated sedimentary sequences. There is an economic constraint here, but it also restricts our knowledge. Published papers seldom include detailed descriptions or petrology on the “basement” thus encountered, and it appears that few of these rocks at total depth were cored for detailed study or dating.

If, and this is a big “if”, continental drift, as a mechanism separating the American continents from Europe and Africa is ever to be proved or disproved conclusively, the age of unquestioned ancient oceanic crust (not postulated “new” crust) below the oldest surface sediments and the first volcanics next penetrated, must be determined and mapped . If drilling is halted at the first sign of basalt or other volcanic-metamorphic- plutonic rocks and this is called “basement” without further analysis and dating, this is unsatisfactory. The method apparently employed to ascertain ages at TD on many DSDP holes may well have been terribly misleading. (Meyerhoff, A. et. al. 1992)

Even if it is assumed that continental drift has, in fact, occurred on the scale postulated, and is continuing, we still do not know at what level in the asthenosphere this “slippage” has taken place, or, by what means. A better knowledge of the “basement” could lead us to new answers.
New evidence on mantle and lower crustal rocks commonly exposed along the Mid-Atlantic ridge and other postulated “spreading ridges is needed. Our understanding of the mechanism of ocean ridge construction must also be closely re-examined. (Tisseau & Tonnerre 1995), (Michael, P. et al 2003).

What is needed is more data on the oceanic “basement” from deep drilling. We need the age and lithology of “basement” below the oldest sediments at appropriate locations spaced along E-W lines in the north and south Atlantic, shore to shore between the continents. Three to four carefully selected lines should be sufficient.

* *

21.1 Discussion #1

THE MIGHTY OCEANIC CRUST

It is generally agreed that the oceanic crust is thin and structurally weak. Many authors have published thickness figures in the range of 5 - 9 km. A few have made estimates of up to 40 km.
All available evidence indicates that oceanic crust, on average, is thinner and weaker than the continental plates. If this is true, a serious problem is posed.

How can a thin, weak, oceanic slab, which is said to sink passively into trenches and dive under continental margins to a doom deep in the asthenosphere, generate enough compressional force
to produce lengthy mountain ranges such as the Cordillera, the Rocky Mountains, the Cascades and the lesser Coastal Ranges?

The sinking of these “cold oceanic slabs” is also held responsible for generating a concentrated zone of both shallow and deep earthquakes and a ubiquitous line of volcanoes set back from trenches in a circum-pacific basin “ring of Fire.”

Consider especially, the mechanical relationships: Here is a thin weak oceanic crust (supposedly transported in conveyer belt fashion by a sub-crustal convection current) impinging in a half-hearted manner on the margin of a much thicker, stronger, continental plate causing, thereby, the latter to be folded, faulted, thrust, and uplifted multiple thousands of feet over lengths of thousands of miles, and widths of hundreds of miles. It does this, seemingly, with little apparent deformation to the impinging oceanic crust!

The answer to the original question is that it can’t. This standard prototype picture just doesn’t compute. Something is drastically wrong here!

Age of the Oceanic Crust

Based on present knowledge, the age of the oceanic crust nearly world-wide is dominantly Cretaceous (146 Ma), or younger. A few scattered small patches around the world are dated back to 180 Ma. (Jurassic).Two are located in the north Atlantic; one is off the coast of N.W. Africa and Jurassic Red Beds have been drilled offshore the east coast of North America.

A third area, The “Great Oyashiio Paleoland“, is not composed of oceanic crust, but is underlain by continental rocks dated as Archean, Proterozoic, and Paleozoic This includes Cambrian and Ordovician to Neogene layers (Choi, Vasil’yev and Bhat 1992) and (Choi, D.R.1987). This large area is in the NW Pacific Ocean east of the Japan and Kuril Trenches.

Plate tectonic theory, of course, accounts for the “absence” of pre-Jurassic rocks by postulating a steady creation of new crust at various mid-ocean ridge genesis locations while older crust along continental margins is being destroyed in subduction zones. This concept, also, raises important questions:
Was this same mechanistic process operational in earlier times? For example, in the Paleozoic?

The Proterozoic? The Archean? Plate theory proponents would perhaps answer affirmatively. If so, they would argue that the process has long been operational and that all older oceanic crust was simply chewed up and destroyed ----ignoring the exceptions cited above. Perhaps, yet seemingly this case would require the fortuitous destruction of nearly all of the roughly 60 % of the Earth's surface that constitutes the oceanic crust, and that presumably existed in approximately similar (or greater) proportion since the Archean. Little of this ancient oceanic crust apparently remains, or, has been identified by dredging and drilling. Yet, if we pursue this idea, some rather exceptional circumstances and assumptions are required.

First, the postulated absence of crust older than Jurassic would require a universal and very efficient mechanism. One that impinged the margins of every continental land mass , sweeping clean nearly every scrap of ancient crust (not plastered to a continent) to a reincarnation beneath its continental companion.

Possible, but that is asking much of circumstance and probability. Such postulation, I believe, would also require a veritable caldron of thermal plumes in the upper mantle, rising first here, then there, to create spreading center "brooms" to sweep away the old crust; and, at the same time breaking apart Gondwanaland, allowing the pieces to float freely on a sea of thermal whimsy. (This is not necessarily an argument against Drift).

This leads to further questions. If the thermal convection centers were active since at least the early Proterozoic, or even the Archean, and these were key to the mechanism that later dispersed Laurentia and Gondwana land masses, how did this supercontinent accrete in the first place?

In an environment of multiple spreading centers worldwide, it would seem that by whatever processes the original virgin materials differentiated to form granitic continental areas(Priscoan >4.0 billion yrs. BP), these areas would have been in scattered locations rather than concentrated in one single large landmass. To postulate a continental drift theory which, rather late in geologic history, dispersed this large supercontinent to its present continental components would require some mechanism to have accreted it originally.

Yet, it immediately becomes apparent that such a mechanism would be at odds with an hypothesis that convection currents were active early in Earth's history, and, if not then, why now?

Thus, the hypothesis that plate tectonics provide a harmonious complement to Continental Drift is not one of harmony at all, but, in fact, the two ideas are in substantial conflict.

It must be kept in mind, also, that the oceanic basins cover approximately 130 million sq. miles of Earth's surface. In spite of the thousands of dredge hauls and hundreds of DSDP drill holes drilled in the Atlantic, Pacific, and Indian Ocean basins, our knowledge of oceanic crust apart from seismic refraction surveys and CDP seismic profiles, is indeed very limited.----most sampling barely scratches the surface, literally.

In those sites where DSDP holes have been drilled, economic considerations often limited their depths. The penetration of basalt below soft, easy drilling in sediments has usually marked total depth. The basalt may then have been deemed to be “basement.” when in fact the basalt, thus termed, often carried chilled, fine grained, selvedges and the sediments above often displayed baking (Meyerhoff, A., et al 1992 p.168). Both of these features are of course, characteristic of intrusive *sills*, not basement.

Age determinations based on such questionable data are of limited value in studies made to ascertain evidence of crustal “spreading.” Moreover, we are left with meager knowledge of whether or not layers of older pre-Jurassic rocks may be hidden at depth under older basalt.

*   *   *

21.3 MECHANISM OF CRUSTAL FORMATION

If new oceanic crust is formed by the solidification of injected magma into vertical zones of weakness and separation resulting from the tension created by the parting of sub-crustal convection currents, then WHY is there not a dominance of vertically oriented solidified basaltic magma comprising the oceanic crust over most of the world's sea floors? Would not most of the oceanic crust have been created vertically and be stacked together like a deck of cards standing on end?

Based on limited data obtained by submersible observations, and as reported in the literature, this seems not to be the case where basalt has been observed in faulted sub-sea cliff faces.
The "vertical dike zone" in ophiolites and where this zone has been observed in sea-floor exposures, appears much too thin to represent (or result from) this element of the postulated spreading mechanism.

A major argument against spreading can be stated with a question:

What mechanism operating at a spreading center can create crust so that equal quantities (measured horizontally) are uniformly and consistently generated on either side of a spreading center that is configured in a straight line over distances of up to 400 to 600 miles and that maintains it's straightness for hundreds, hundreds of thousands, even millions of years, with no significant change in rate of flow, or equality of division in creation of new crust?

The new crust must also be transported by the drag of a sub-crustal convection current that splits in equal parts at the center of this remarkable creation process, then both move orthogonally from the center so that each half travels at the same rate, over equal distances during hundreds of thousands of years-----that this entire process continues through repeated reversals of Earth's magnetic polarity over millions of years to produce a series of essentially parallel magnetic zones mapped as alternating "zebra stripes" said to *prove* the hypothesis of sea-floor spreading.

Now, we may answer the not so rhetorical question posed earlier in this discussion.

There is no such mechanism operating on oceanic ridges deemed to be "spreading centers." The sequence of events and the parameters required producing the bi-laterally uniform magnetic reversals offered to prove the existence of new crystal creation and the spreading across ocean floors in the same systematic and uniform manner in all the major oceans of the world beggars the imagination.

Nothing ever observed in the history of geological science will support the conditions required to posit magnetic stripes as proof of oceanic crustal creation and sea-floor spreading.

The existence of magnetic reversals in Earth's poles and the mapped stripes in oceanic crust is well documented by excellent research. The interpretation of origin and meaning of these stripes in oceanic crust is still unknown and yet to be discovered.

21.4 A MELANGE OF CRUSTAL FORCES

The visual result of crustal disturbance takes many forms. Competent scientists usually record, accurately, the facts of a physical setting along with the observed details for particular features under study. A problem may arise when the observer attempts to synthesize and explain the observed facts in terms of an over-all tectonic environment or sequence of events that produced the features observed.

> *"The expectations of theory color perception to such a degree that new notions seldom rise from facts collected under old pictures of the world. New pictures must cast their influence before facts can be seen in a different perspective."*
>
> Stephen Jay Gould
>
> Introduction to: *Fossils* By: Niles Eldredge, 1991

It is natural that the framework of concepts carried into the "field" will dominate the researcher's interpretations in fitting the data into an explainable and acceptable sequence of crustal processes. Often this reservoir of working concepts, based upon the 'reigning criteria for scientific belief' is limited in scope or erroneous.

Unfortunately, that is the situation we face today. The "tools" available for synthesis and the placing of major crustal features into the framework of dynamic crustal processes is based largely on the widely accepted elements of convection, sea-floor spreading, and subduction. Even if these ideas are correct, which this author seriously questions, there remains a large array of observations which pose problems that are not answered by these elements of the Plate Tectonics hypothesis.

The concept of continental drift, though gaining in supportive evidence, imposes dynamic forces which should be considered separately. Why? The driving forces for plate motion may not be related to convection, or spreading or, even the factors attributed to the increase in gravity. The kinetics of any plate motion, will however be admixed with the kinetics and dynamics of forces stemming from the increase in net (g). This will add to the over-all complexity of a synthesis.

The "unfortunate" part arises from the fact that earth scientists have ignored or failed to recognize the effects of Earth's deceleration and the important role that a slow increase in net gravity plays in the tectonic forum. Thus, scientists are deprived of a major component of dynamism for a complete lexicon of tectonic forces. This seriously hampers the scientist in developing reasonable (shall we say accurate?) answers toward understanding the complex processes at work.

Earth's slowly increasing gravity provides additional or alternate answers to problems frequently glossed over in superficial references to vague processes attributed to the regime of Plate Tectonics. Gravity also apparently provides feasible answers to problems for which no answers are provided by Plate Tectonics. In other words, Earth scientists are failing to use the major factor of changing net gravity to explain processes which, beyond question, have logically been active throughout a large part of Earth history.

One deductive conclusion based on the foregoing discussion is that there are additional factors which must be considered in analyzing the complex environment of dynamic forces active in the crust. We must consider a melange of forces, which, at a given geographic location and at a given period in time, may function singly, or, several may interplay simultaneously.

FUNDAMENTAL FORCES KEYED TO DECELERATION

Gravitation:

The value of gravity acceleration is influenced by several physical factors. Most obvious are variations in mantle and crustal density, surface elevation, earth geometry, and latitude. Some of these may change slowly over time, but, their role in tectonics is small and is little affected by earth rotation.

The key factor in triggering a host of effects is the reduction in centrifugal force (Fc). The resulting increase in *net gravity* sets in motion forces that are superimposed on the factors above. (Variations with time are discussed elsewhere and are illustrated in figures and Tables) Among these effects are an increase in Earth's internal density, and a reduction in surface area. As Earth decelerates the maximum change in net gravity occurs at the equator, diminishing to zero at the poles by the cosine of latitude. Polar gravity is, therefore, where "static" gravity prevails and the effects of Fc are indirect.

Horizontal Compressional Stress

Earth deceleration is at the base of all succeeding processes including increasing gravity, and increased weight in the crust, lithosphere and mantle. This weight increase raises internal pressures, reduces internal volume, and reduces Earth's surface area. The end-result influencing tectonic activity is that we have, in over-all aspect, *universal horizontal compression.* Theoretically, compressional stress vectors at any given point are oriented toward that point from 360 degrees. This stress field may, of course, be modified by other conditions such as the reduction of oblateness and the related kinematic movements discussed below. (including lunar forces related to drift)

Gravitation Density Movements

These are the vertical rising and sinking of crustal segments moving in consort with increasing values of gravity. They are related to Earth's heterogeneous lithic density. Their geographic scale on continents ranges from localized domes, to mountain chains, to epeiric (isostatic) adjustments over large regions. This mechanism is explained and distinguished from processes attributed to thermal convection in the sections on *Gravity* and *Gravitation Density Cells*.

In ocean areas, vertical movements related to density dominate the construction of linear ridges, the deepening of intra-ocean basins, and the over-all sinking of ocean basins world-wide, All such features owe their creation to the combined effects of slowly increasing *net gravity* functioning under conditions imposed by compression, density, the geometry of an oblate sphere, isostatic adjustment, and other stress controlling mechanisms.

While these kinetic movements are inter-related they do not necessarily occur *pari passu* in time. There may be delays or continuing adjustments over tens of millions of years. This is an important point since it leads to an understanding of how epicontinental seas may be created, exist for long periods, and then be eliminated by elevation. The creation of oceanic arches, the deepening of basins, along with over-all oceanic subsidence, and reduction of world surface area will affect eustatic sea-levels world-wide. At the same time dense (>3.4) mobile magma underlying the ocean basins will slowly tend to migrate toward and under continental plates (<2.7) to effect isostatic balance and epeirogenic adjustments.

Conceptually, the forces involved in *Gravitation Density Cells*, diapirs, isostacy, ocean-floor subsidence, and continental epeirogeny, are all inter-related; all are controlled by gravity. However, diapers, (e.g. salt) and isostatic adjustments, may result from other geologic factors even under conditions of stable gravity. Gravitation density cells, the formation of intra-ocean basins, rises, ridges, and epeirogenic movements all appear to be primarily activated only by the slow increase in *net* gravity. It is useful, therefore, to briefly distinguish these separate mechanisms.

Gravitation Density "cells" are universal. The process is involved in the building of isolated ocean ridges, the world-wide pattern of linear "mid-ocean" ridges, island archipelagoes, suspected "hot spots", and probably most continental mountains cored by granite or other low density silicic rocks. The tendency for uplift attributable to this mechanism where low density rocks are deep rooted may well be operational presently. The areal geometry of deformation, whether linear, curved, or otherwise configured, and its directional orientation is largely controlled by horizontal compression and the material strength of lithologies involved.
Density "cells" may be thought of as "handmaidens" to, and work in partnership with, forces of compression.

Diapirism: While gravitation cells do function diapirically, this term should be retained as presently used.

World-Wide Subsidence of Ocean Floors has been noted and discussed by a host of authors

beginning with Darwin's (1895) interpretation of southwest Pacific atolls. Areas of substantial subsidence (up to 5500 meters) have been described by Resanov (1978) and others in each of the three major oceans. Data obtained by the decade-long Deep Sea Drilling Program (DSDP) discussed by Resanov (1978), Ruditch (1990) and others, prove wide-spread subsidence active at least as far back as early Jurassic.
Data from four hundred widely dispersed DSDP boreholes analyzed by Ruditch repeatedly demonstrated that in presently deep basins (and some shallower) older shallow-water sediments penetrated deep in the drilled sequences were succeeded up-section by deep-water sedimentation.

Stated more succinctly, older sediments were initially deposited in conditions of shallow water.
The region then started to sink while sedimentation continued in increasingly deeper waters.
This relationship was found present in (19 boreholes out of 402):

Pacific Ocean:	transition shallow to deep ------	1st half of Cretaceous
Atlantic Ocean:	" " " " ------	Paleocene
Indian Ocean	" " " " ------	Oligocene

Ruditch called the areas of major subsidence, "*mosaic*" basins resulting from uncompensated subsidence attributable to "basification" of old continental crust.
Rudditch concluded that the foregoing relationships absolutely preclude conditions developed by a sea-floor spreading mechanism —a view shared by this author.

Plate Marginal Oceanic Trenches

Gravity and compression jointly triggering isostatic adjustment appear to be the principal forces applied to adjacent crustal plates of different density to create ocean trenches. Where trenches follow closely along continental margins as they do around much of the Pacific basin, this suggestion seems to work. However, along the east coasts of south and North America, Africa, and the Mariana trench in the Pacific, this attribution of mechanism is less convincing. It may be that continental drift plays a role in trench formation not yet perceived. In any event, the postulated idea of subduction is hereby rejected totally.

Epeirogeny

Continental epeirogeny and the subsidence of ocean floors are opposite but inter-related members of the same tectonic processes keyed to increasing net gravity. In essence these are reactions to gravity and its effects on large areas of crust that are of different density and mass. Namely, thin crusted oceanic basins floored with basalt and underlain by denser magma, as contrasted with thick continental plates made up of lighter silicic metamorphic and granitic components.

Stated differently, it is "isostatic" adjustment on a megascale. This is adjustment that extends over long periods of geologic time. Conceptually, it is unlikely that isostatic equilibrium is ever fully achieved due to the many inter-related dynamic forces keyed to Earth's deceleration, and so, crustal unrest continues.

Epeirogeny and sea-floor subsidence are discussed in sections 12.0, 13.0, and 14.0. Briefly explained: Increasing net gravity loads the sea-floor and dense underlying mantle causing increased pressure at depth. A similar loading and pressure increase occurs below adjoining continental plates. However, the increase in PSI is less under continents than the PSI under ocean plates at equivalent depths. Plastic or fluid magma will thus flow laterally from beneath the ocean plate to areas of less pressure beneath the continental plate

Over long periods of time the net result will be oceanic subsidence versus the possibility of vertical fluctuation in the continental plate. Initially, the latter may subside (though less) and then be elevated along its margin. As magma flow continues, it may be re-elevated over-all to a more-or-less stable elevation.

During this on-going process, differences of density in localized oceanic regions may result in the development of deep basins, and when coupled with compression and density cells, elevated ridges may be created. Similar vertical movements are also likely on land. Vertical movement of the ocean floor will alter eustatic sea-levels while any change in relative continental elevations may create shallow Epi-continental marine troughs and embayments, then later destroy them.

Plate Mobilism (speculative)

Since little about the dynamic forces related to the “drift” of crustal plates is presently known, or for that matter, to what extent plates may actually have been displaced, the derivative kinematic motion and its superposition on, and integration into, tectonic forces attributable to gravitation and compression necessarily complicates an analysis. This also makes any posited effects very speculative.

Non-the-less, a recognition of possible drift added to the melange of other crustal forces, has a value in keeping investigators alert to all possible stress elements. If we assume for discussion, plate motion effects independent of the mechanisms cited above, these speculations are more understandable.

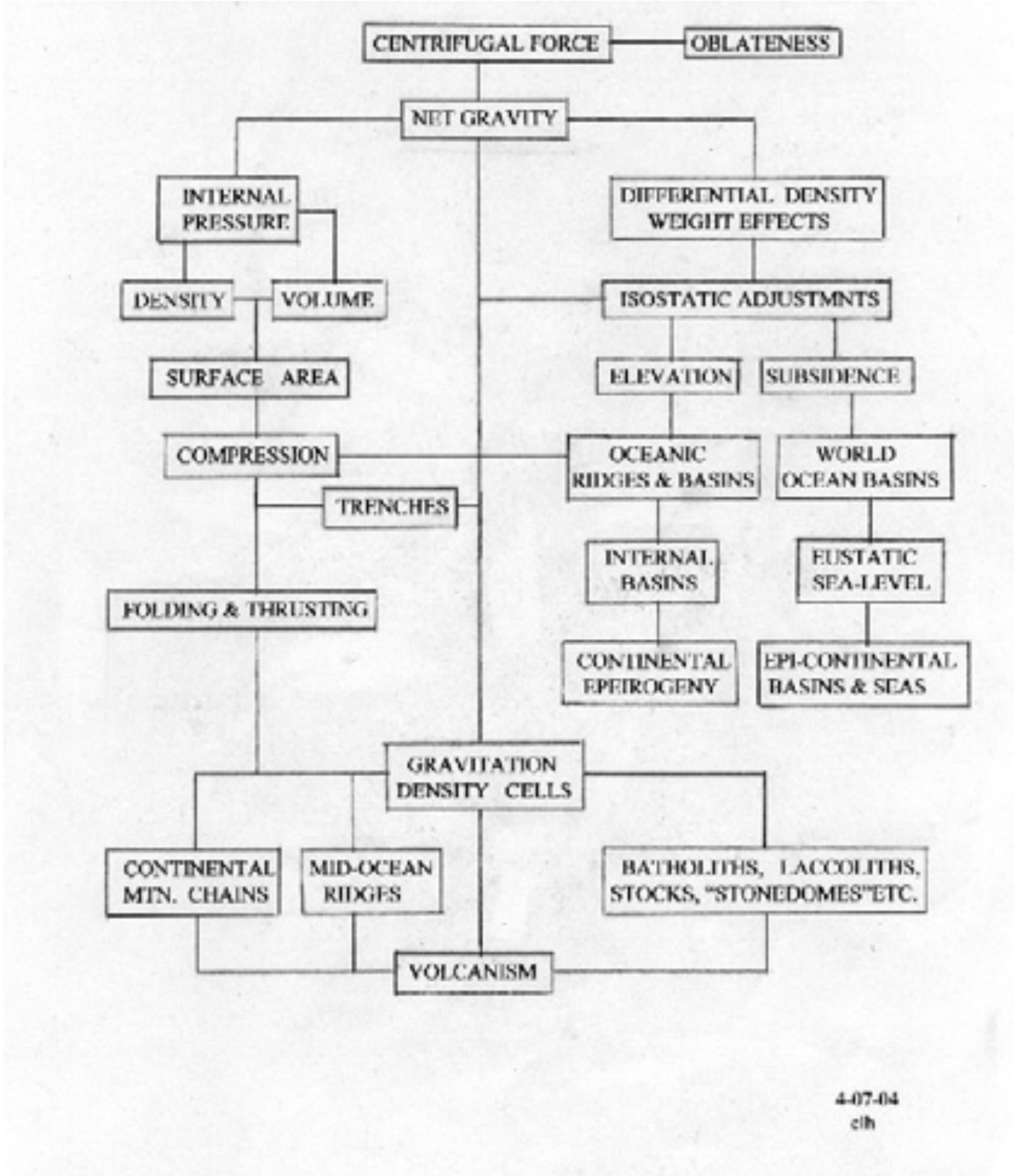
Horizontal motion of a structurally competent crustal unit relative to surrounding units can produce at localities along its margins; compression; strike slip shearing; or zones of rifting and tension. The dynamic force causing motion in one competent plate is likely also, to have some (though perhaps less) influence on adjacent plates, along with transmitted stresses between plates.

In this model we are also postulating force vectors generated dominantly from Earth’s tidal bulge and directed westward. At other times in Earth history, northerly and southerly directed forces may have been generated by Lunar gravity related to the angle between the Moon’s orbital plane, Earth’s equator, and the variable position of landmasses above or below the equator over long periods of time. These ideas appear compatible with known physical laws but require close mathematical analysis (see section 20.0). Meanwhile, they serve to focus attention on an array of conflicting facts and ideas that hold sway in published literature as the “prevailing science.”

* * *

21.4.1 **EARTH DECELERATION EFFECTS**

Diagram of Inter-related Effects on Crustal Dynamics



21.5 A CLOSING THOUGHT

It seems appropriate to leave the reader with some pertinent conclusions stated by Sir Alan H. Cook, Selwyn College, Cambridge:

THE MOTION OF THE MOON (1988) 222 Pgs.
Publisher, Adam Hilger, Bristol and Philadelphia

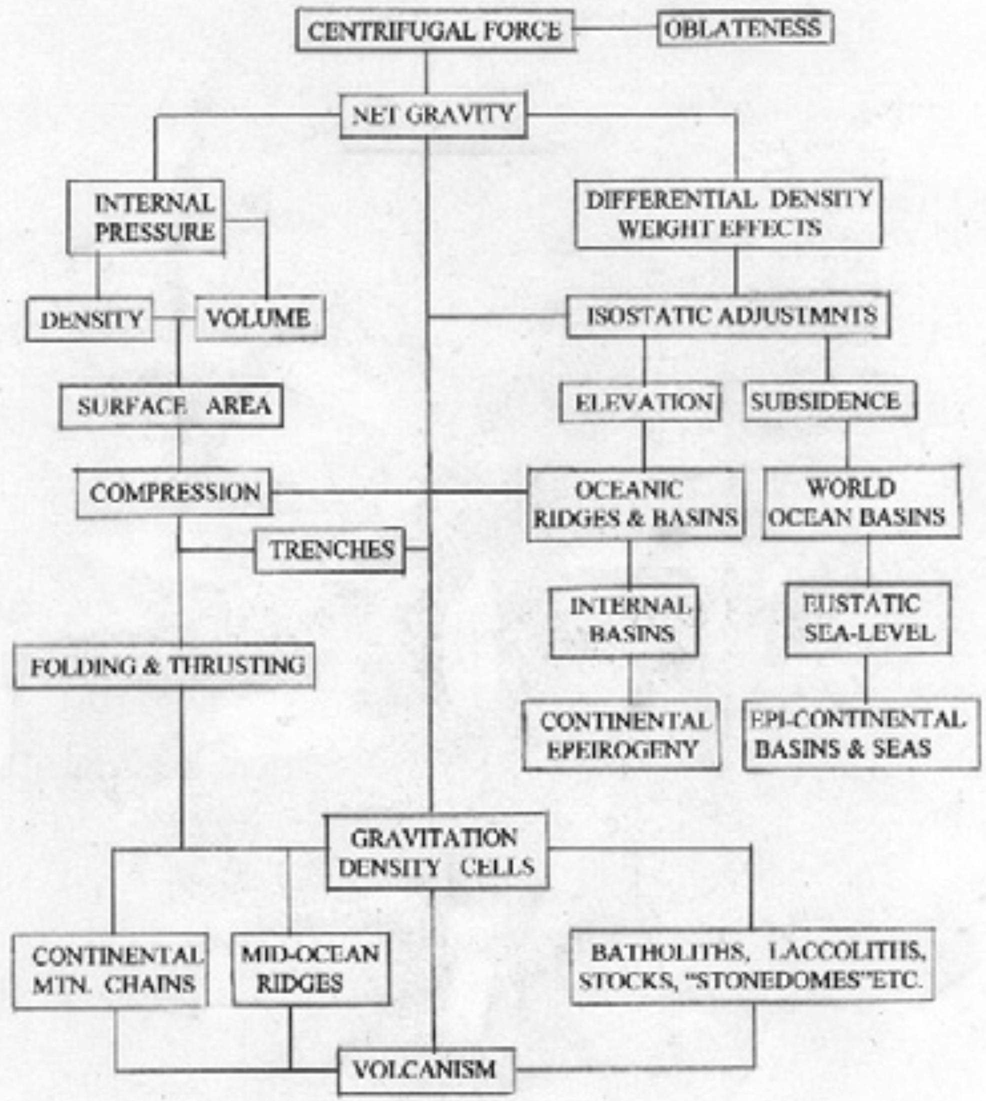
This book is primarily a venue for persons trained in advanced mathematics with backgrounds in geophysics. However, Cook was kind enough state in understandable English some conclusions that are most important to the hypotheses and concepts proposed by the present author.

> "The theories that have been described in this book (above) all depend on the supposition that the Earth and the moon are rigid, and that they do not deform elastically as the forces acting on them change. This is clearly wrong. The Earth is covered with oceans that move over its surface, driven by the tidal forces exerted by the Sun and the Moon, while the solid elastic body of the Earth deforms under the direct tidal attraction of the Sun and the Moon and the varying loads of the oceans as they move over the surface. The moon likewise is elastic and deforms under the tidal forces of the attractions of the Sun and Earth, which on account of different speeds of rotation of the Earth and the Moon upon their polar axes have an essentially monthly period rather than a diurnal period."
>
> "The magnitudes of the effects of tidal yielding and dissipation at the present time justify their neglect in theories of the lunar orbit over a few centuries, with the exception of the secular acceleration. On the other hand, in discussions of the evolution of the system of the Earth and the Moon over thousands of millions of years, tidal dissipation and elastic yielding are not *just* not negligible, they control the course and history of the system."
> "The distance of the moon from the Earth has changed by large factors as a consequence of tidal dissipation, which was much greater when the two were much closer than now, and the angular velocity of the Moon about her polar axis would not be equal to her orbital angular velocity without elastic losses within her. Such matters are outside the scope of this book, which is concerned with lunar dynamics over relatively short time spans of a few centuries, but recent discussions include those of Tokis (1974) who considers the effect of viscosity on the dynamics of the system of the Earth and the Moon, and of Mignard (1981) who deals with evolution of a system of three bodies having dissipation from internal tides, and argues that the Moon was much closer to the Earth with a greater inclination and a smaller obliquity."
>
> "The study of the Moon has had a major influence in geophysics, most evidently in the study of the tides and what they reveal about the evolution of the system of the Earth and the Moon and about the gross physical properties of the Earth.

* * * *

EARTH'S DECELERATION

A Diagram of Inter-related Effects on Crustal Dynamics



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DISCUSSION OUTLINE #3

3-14-04

FUNDAMENTAL TECTONIC ELEMENTS (keyed to deceleration)

Gravitation: An increase in net (g) commensurate with deceleration. Maximum at the equator, diminishing toward the poles by the cosine of latitude.

Horizontal Compressional stress resulting from Earth's surface reduction and the change in geometry from reduction of oblateness toward a sphere.

"Gravitation Density" movements' .The rising and sinking of crustal segments related to heterogeneous lithic density.

* Universal density diapirism: isolated oceanic ridges, and a world-wide pattern of linear "mid-ocean" ridges, & island arcs.
* World-wide subsidence of the major ocean sea-floors.
* Plate marginal oceanic trenches coupled with compression.

Isostatic Generation of granitic batholiths, laccoliths, stocks, "stonedomes", linear and non-linear mountain ranges, and, the maintenance of elevation in granitic cored mountains by continuing density (weight) controlled uplift over long periods of time.

Epeirogeny

* Regional isostatic adjustments and eustatic changes in sea-level.
* Elevation/depression of continents and world-wide subsidence of ocean basins.

CONTINENTAL MOBILISM ("drift") (speculative)

* Westerly force vectors - Generated by Lunar gravity on the tidal bulge and by heterogeneity of density in the Earth's crust.
* Northerly and southerly force vectors generated by lunar gravity depending upon the geometry (angle) between the Moon's orbital plane, Earth's equator, and the position of continental land masses above or below the equator. (variable over geologic time)
* Compression, and strike-slip shearing
* Zones of tension or rifting.

SECONDARY TECTONIC ELEMENTS (partial list)

* Gravity sliding off major regional uplifts
* Gravity sliding off dipping flanks of subsiding sedimentary basins to produce compressional folds within the basin parallel to the basin axis.
* Volcanism, degassing, and plateau or flood basalts.

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(To better understand “Our Dynamic Earth and the Length of Day)

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The following plotted chart depicts hypothetical changes in:

EARTH SURFACE AREA Versus PERCENT CHANGE IN AVERAGE INTERNAL DENSITY

The figures for % of change in density are arbitrary. They were used to calculate the change in Earth volume, and from this a change in total surface area.

(present average Earth density is 5.52)

Density.increase from a paleo-value of: Yields a reduction in surface area of:

4.97 to 5.52	(10.0%)	14.3 million sq. miles
5.24 to 5.52	(5.0%)	6.8 million sq. miles
5.46 to 5.52	(1.1%)	1.3 million sq. miles

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