THE CREATION OF MAJOR PLANETARY LAND FORMS THROUGH THE CAPTURE AND ACCRETION OF SEGMENTS OF A COMET'S TAIL

MILTON ZYSMAN
Comimi Research Inc.

Edited by
MARIUS OLTEAN
and
HEIKO SANTOSH

© 2010 by
Comimi Research Inc.
Suite 501, 44 Walmer Road
Toronto, Ontario M5R2X5
Ph no: 416-922-1542
Cell no: 416-566-7518
mbz41@sympatico.ca

Note on publication: A draft of this paper was prepared and distributed in 2003. It was revised to provide missing references and to clarify language and typos.

CONTENTS

ABSTRACT 7
PREFACE 8
PART ONE: MOUNTAIN BELTS 11
Endogeny and Exogeny 11
Exogeny 11
Draining the Oceans 12
Trying to Make Sense of Eros 13
The Two-Dimensional World of Comets 15
The Elusive Debris Tail 16
The "Bellyband" of Iapetus 18
Schematic of a Mountain Belt 19
Essential Character of a Mountain Belt 20
PART TWO: THE RIBBON/RIDGE EQUATION 23
The Ribbon/Jet Connection 23
Falling Ribbons 25
Capturing Mountains 25
Mountain Ridge Formation 26
The Opening Argument 27
Mountain Belts and Topography 27
The Appalachians 28
A Rock Monopoly 29
Mountain Belts and Evolution 29
Endogeny Challenged 30
Exogeny is Not Catastrophism 31
Overnight Mountain Belts 31

The World of Rock 32
Categorizing Rock 32
What Is Sediment? 33
The Earth's Shell and Topography 33
Mountains, Earthquakes, Volcanoes and Non-Igneous Rocks 34
Looking up 35
The Chemical Disparity between Igneous and Non-Igneous Rock 35
"A penultimate silicate froth": The Alien Crust 36
The Case for Travelling Mountain Belts 37
"One can still marvel at the recent change of paradigms …" 38
Mountain-Moving Problems 38
Mountain Folding 39
The Persistence of Folding 41
PART THREE: LOOKING OVERHEAD 42
The Comet as Cosmic Mill 43
The Value of Minor Ridge Systems 43
Establishing Ribbons 44
Striae 44
The Meteor Storm as Endgame 45
Ring Tones 46
Amalthea and Thebe 47
Showers 49
Splitting and Ribbon-Making 52
Mountains Are Not Cone Volcanoes 54
The Norwood Eskers 55
An Esker Is A Naked Drumlin 57
The Individual Band as Ridge-Maker 58
Spreading And Wheeling 59
Ridge Discontinuities 59
Explaining Escarpments 60
An Ancestral Message 61

Macroscopic Features of a Cometary Hypothesis 62
PART FOUR: SEDIMENT AND EARTH HISTORY – THE DIMENSION oF TIME 63
The Time Dimension 64
Bedding Surfaces 64
The Grand Canyon 64
The Uniformitarian World 65
Unconformities - Missing Earth History 66
Explaining Unconformities and Bedding Surfaces 67
Early Ideas on Erosion 67
Sediment Disposal – Too Much or Too Little? 68
Computing Sedimentary Output 68
The Rate of Denudation 69
Sourcing Sediment 70
Lyell's Rationale for Sedimentary Production 70
The Pristine Appalachians 71
Where Did All the Regolith go? 71
The Glomar Challenger 71
A Solution to the Sediment Paradox 73
Mountain Belts: A Concrete Solution 73
The 'True Rocks' 73
The Properties of Cement 74
Recent Cementing Operations 75
Loess 75
Chemistry 75
Domain 76
Loess's Provenance 76
Northern China 77
The Cometary Origin of Loess 78
Other Cemented Landscapes 79
PART 5: LOOKING UNDER 80
Seafloor Exploration 80

The Earth's Greatest Mountain Belt 81
Plate-Tectonics and the Mid-Oceanic Ridge 81
Do Mountains Move Apart? 83
Once a Mountain Belt, Always a Mountain Belt 83
When is a Ridge a Mountain? 83
Does the Mid-Oceanic Ridge Meet Cometary Criteria? 84
The Continuity of Mountain Belts 84
Ridges, Sea Mounts and Abyssal Hills 85
Do Plates Move Apart? 86
Gaps in the Mid-Oceanic Ridge 86
Is There any Evidence That the Mid-Atlantic Ridge Moves Apart? 87
Escaping Magma 87
Zones of Reversed Polarity 88
Acquiring Reversed Polarity 89
The Mountain Belt: Its Source, Structure and Centrality to Exogeny 90
Energy Requirements 91
Conclusion: Back to the "Penultimate Silicate Froth" 92
REFERENCES 94

ABSTRACT

This paper advocates an extraterrestrial origin for the earth's major landforms. It contends that this planet's great continental and sub-oceanic mountain ranges, and the deep layers of sediments found adjacent to them, are cometary debris. These mountain belts are the direct and immediate result of the earth's capture and laydown of a segment of a great comet's tail.

PREFACE

Despite the traditional feelings of awe and fear inspired by comets, some have credited them with benign traits. Isaac Newton believed them to be water carriers, maintaining each planet's mass by replenishing the water lost through evaporation, thus keeping a balance in his clockwork universe. In the *Principia*, he writes: "[...] for all vegetables entirely derive their growths from fluids, and afterwards in great measure, are turned into dry earth by putrefaction [...] I suspect, moreover, that it is chiefly from the comets that spirit comes, which is indeed the smallest but most subtle and useful part of our air, and so much required to sustain the life of all things with us." [1] More recently, comets have been given the credit for seeding our planet with life-giving microbes. No one yet, however, has had the temerity to claim that mountain belts, the solar system's most prominent surface features, has come from outer space.

I was forced to this conclusion during the final stages of publishing "Tails of a Recent Comet" in 1997 [2]. The paper claimed a cometary origin for esker (illustration 1) and drumlin (illustration 2) super-swarms. These radiating ridges of sand and gravel cover thousands of square kilometres in the northern regions of North America and Eurasia (illustration 3).

It was this paper that generated this radical excursion into orogeny (mountain building). The work focused on the New Quebec super-swarm and drew particular attention to the Trent River, which snakes its way to Lake Ontario, flowing through a field of eskers and drumlins.

This image plucked at my memory, for I recalled maps of the Susquehanna River which wove a very similar path through the Appalachians on its way down to the Atlantic. Except for scale the two systems – the former claiming a glacial and the latter a plate tectonic origin – they appeared almost identical.

Illustration 1 *Classic example of an esker, northeast of Artillery Lake, North West Territories, Canada.*

Illustration 2 *Classic example of a drumlin.*

Both ridge types had the same discontinuous triangulated profile, displaying similar offset gaps, through which their rivers meandered. All formations, independent of

scale, displayed long cliff-like drops (escarpments). Moreover, each system always kept the escarpment on the same side.

I was aware of the unsettled question of both mountain belt and esker /drumlin origin, and knew that their non-igneous interiors were fossil-free. When further research uncovered virtually identical formations throughout the Solar System, it reinforced my intuition that comets had a major creative role in both geological and organic evolution.

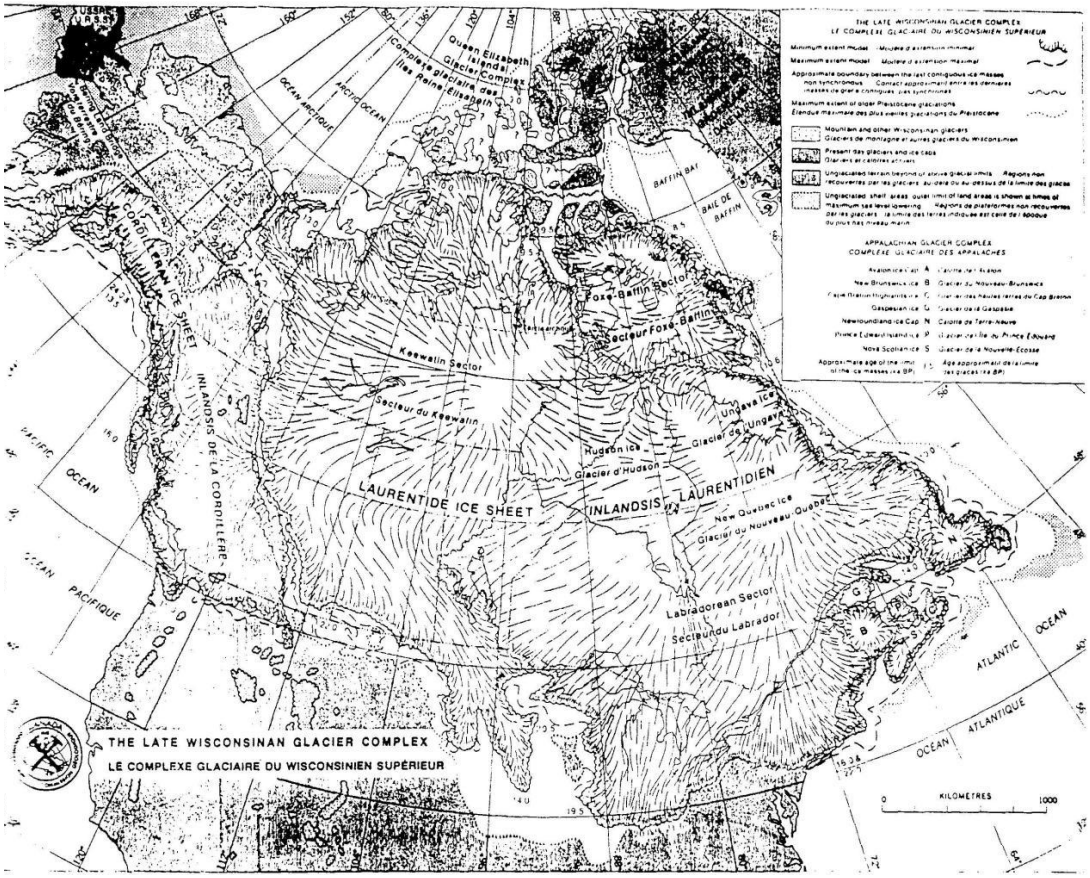

Illustration 3 *Map of North America showing the radiating pattern of the New Quebec esker/drumlin super-swarm (in the northeast) and the Keewatin super-swarm (in the northwest).*

PART ONE: MOUNTAIN BELTS

ENDOGENY AND EXOGENY

Theories of crustal formation, both old and new, retain the same basic premise: the earth imperceptibly recycles its crust by converting molten rock to mountain ranges, which erode into fossil-bearing strata. These formations are eventually transported back into the earth to melt and emerge again into renewed crust.

This prevailing geological theory is called 'endogeny'. The opposing hypothesis – to be explored below – I will refer to as 'exogeny'.

EXOGENY

A successful exogenic model for orogeny, for better or worse, breaks virtually every doctrine supporting the earth sciences.

The first and most precious is the dogma of Deep Time, which requires millions of years to build our continents. The earth's mountain belts and their contiguous deep layered sediments are concentrated in two major planet-girdling systems. If mountain belts have arrived virtually overnight, they have obviously done so without the assistance of plate tectonics, presenting an even greater heresy. These assaults on geological doctrine also have profound significance for current theories of organic evolution. The appearance and spread of new species have been associated with evolving mountain ranges. Their overnight delivery would rudely remove the crutch of Deep Time, and would force science to come up with fresh explanations for the evolution of new species.

DRAINING THE OCEANS

The division of the earth into land and sea obscures the fact that ridge systems, both great and small, are the earth's dominant geological feature.

To fully understand the extent and significance of mountain belts, it is necessary to drain the Earth's oceans (illustration 4). It is a task we are better equipped to perform than the fathers of geology, who had only the vaguest idea of what lay at the ocean bottoms. Their telescopes were also too weak to recognize the similar ridge systems found on other Solar System surfaces.

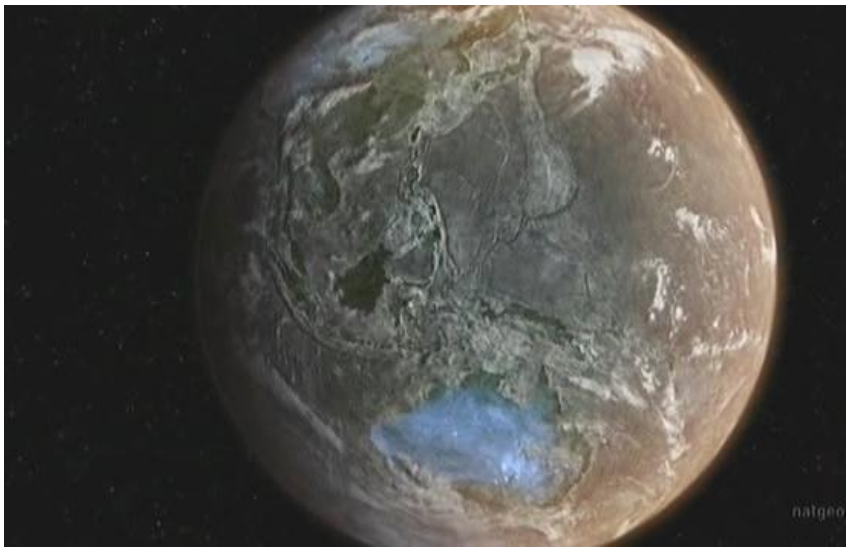

Illustration 4 *What Earth might look like with its oceans drained.*

What we find is that mountain belts, like other planetary ridge systems, both great and small, proliferate across the entire earth. When mountain belts rise above sea level, their characteristic structure forms the borders of continents and defines the extent of great inhabited archipelagos such as Japan and the Philippines.

Stripped of its waters, however, this planet's surface takes on a much closer resemblance to other bodies orbiting the sun. These extra-terrestrial systems have different names, such as Wrinkle, Pucker and Fold Ridges, but they are so similar in structure to the earth's, with their sinuous semi-parallel paths (illustration 5), that both astronomers and geologists turn to earth-bound theories to explain them. For instance, esker and drumlin swarms, which resemble miniature mountain belts, are considered a by-product of glaciers and ancient ice sheets, whereas mountain belts, through a variety of theoretical cycles, are believed to come from the earth's interior.

Conventional geological theory of any sort, however, would be hard put to explain how this particular feature is found on the surface of comets and asteroids (illustration 6).

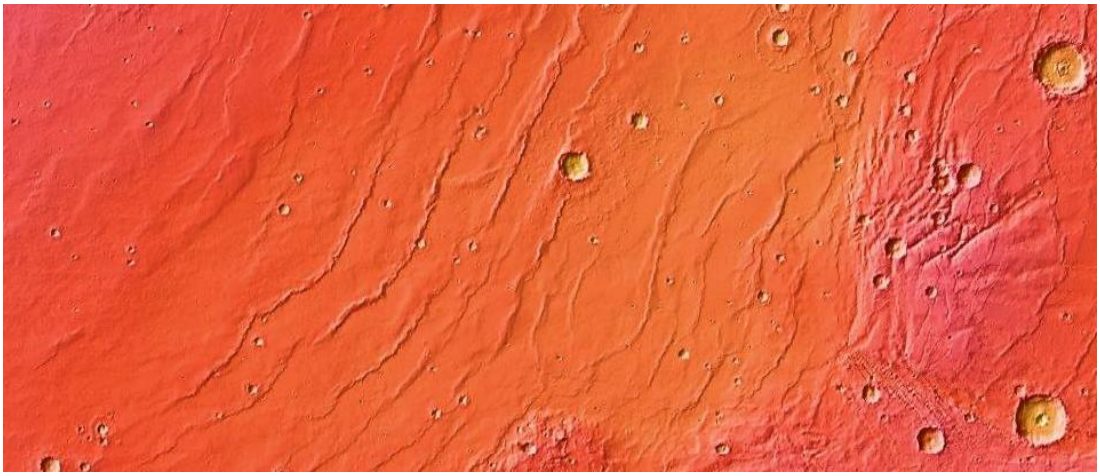

Illustration 5 *Satellite image of Mars near Solis Dorsa. These series of sinuous, semi-parallel ridges are a common feature of the planet's surface.*

Trying to Make Sense of Eros

In a 21 November 2001 news release, Andrew Cheng, NASA's NEAR Project Scientist reported on the first close look at an asteroid:

"We have made fundamental discoveries about Eros: that it is a primitive, undifferentiated body, and that it is a consolidated body, but having established the basic nature of Eros, we are now trying to make sense of what we see when we get up

close [...] From the beginning of the orbital phase, we saw linear features on Eros - for example in the first mosaic released after orbit injection (February 14th, 2000), we noted the roughly parallel lineaments running generally east west on Eros [...]

These lineaments run into the 5-km crater, which we then nicknamed 'the paw' [...]. We showed in the IOD [image] for March 7 the great ridge in Himeros, formerly the 'saddle', without knowing at the time that this ridge actually continues outside of Himeros to over 15 km away, but we did correctly identify it as a structural feature."

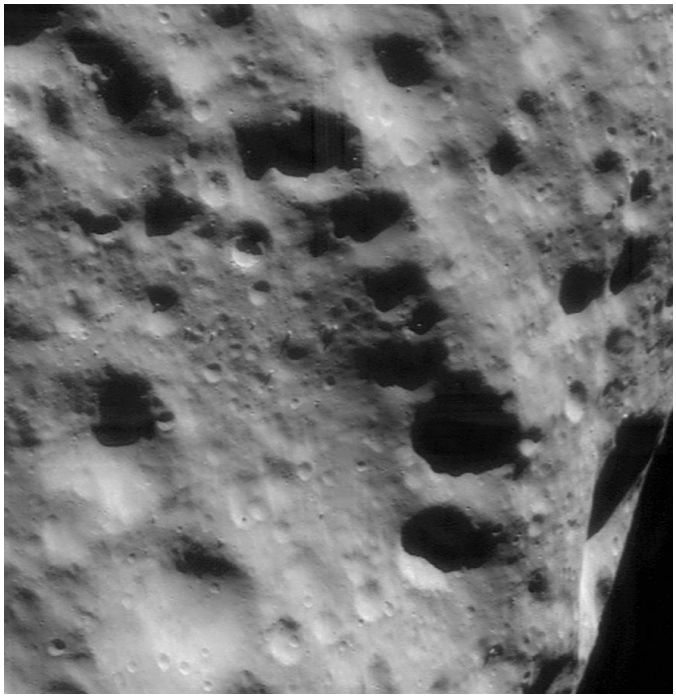

Illustration 6 *Image of Eros taken by NEAR Shoemaker showing one of the asteroid's oldest ridges.*

This expedition to Eros has only added more evidence that ridge systems and their somewhat enigmatic craters are the most common structural features to be found in our Solar System.

On our own planet, ridge systems, both great and small, along with the thick layers of sediments that accompany them, dominate the earth in volume as well as height. They represent more than 80% of the earth's inventory of surface rock, and roughly an equal amount of its volume of loose sediments such as gravel, sand clay.

THE TWO-DIMENSIONAL WORLD OF COMETS

At the heart of an exogenetic model for planetary surface evolution lies the comet's anomalous tail structure. Its three types of tail (illustration 7) spread its gases and debris along its orbital plane and do so independent of the ejecta's composition and direction of motion. This feature first came to the author's attention in a collection of astronomical anomalies compiled by William Corliss: "In all cases the tail material is closely confined to the plane of the orbit. In comets that show more than one type of tail or which show Type 1 streamers, the various structures disappear when Earth passes through the plane of the comet orbit. It is as though one were looking at a sheet of paper edgewise." [3]

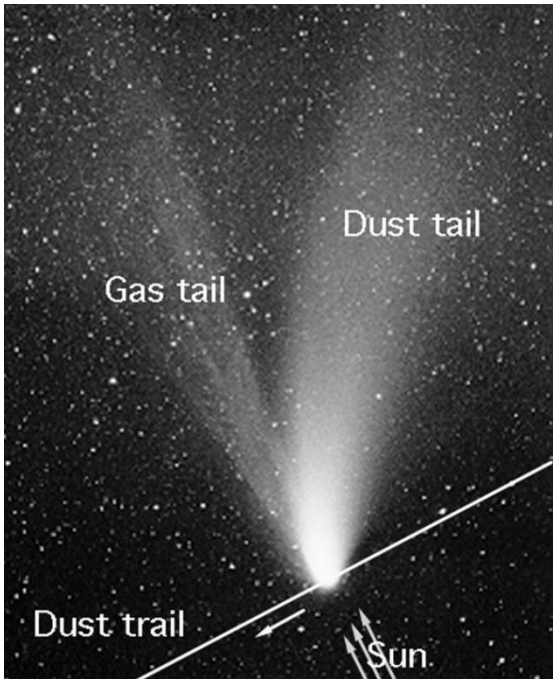

Illustration 7 *Labelled image taken from NASA's website showing the three types of cometary tails. What is labelled here as "dust trail" is most often referred to as "debris trail" and which in this article is simply called "debris tail." Image obtained from* **http://solarsystem.nasa.gov/multimedia/display.cfm?IM_ID=903**.

THE ELUSIVE DEBRIS TAIL

The detailed structure of the two-dimensional debris tail is not well known, even to astronomers themselves.

Telescopes, capable of detecting light from the fluorescing gases and reflecting dust (micron and sub-micron sized particles) in the type 1 and 2 tails, respectively, are ironically insufficient for detecting the larger particles ejected from comet nuclei (millimeter sized and larger), unless the viewing angle with respect to the orbital plane is extremely small (illustration 8). Until sophisticated infrared equipment began imaging the heavier particles [4] (illustration 9), the debris tail was sometimes explained as an artefact of perspective.

Illustration 8 *Image of Comet Lulin taken in February 2009. The viewing angle is just a few degrees above the orbital plane and so we can easily distinguish between the (very thin) debris tail moving to the left of the image (towards the Sun) and the type 1 and 2 tails to the right (away from the Sun).*

Surprisingly, there remains some resistance in popular reference materials on this issue. The *Encyclopaedia Britannica*, for instance, states "The larger particles released from the nucleus, [...] take up orbits that have nearly the same parameters as the parent comet. Some [particles] gain on the comet and others fall behind until eventually an annulus of dust is formed around the comet's orbit." [5]

Illustration 9 *Infrared image taken by the Spitzer Space Telescope of Comet Tempel 2. The Sun is towards the right, and the view is along the comet's orbital plane. The debris tail is composed of the debris to the right (i.e. in the sunward direction) of the coma, which is at the center of the image.*

This misconception is not rare. In the May 11/89 issue of *Nature*, two physicists measuring the mass loss of Halley's comet stated, "Against naïve expectations, the dust particles ejected from the comet are not arranged in some kind of cylinder running the length of the comet's orbit, but are in the form of a thick ribbon like structure." [6]

Furthermore, Zdenek Sekanina reports: "A preliminary examination of the tails of 11 Solar and Heliospheric Observatory (SOHO) sungrazers, observed between 3 and 20 $R_{\odot}$ on their approach to the Sun, provides information on dust ejected from these comets and on the forces to which the microscopic grains are subjected. Images taken at times of the SOHO spacecraft's transit across the orbit planes of sungrazers show their tails to be perfectly straight and extremely narrow and their apparent position coinciding with that of the projected orbit plane. This result suggests relatively low particle-ejection velocities in the direction normal to the orbit plane (estimated at less than ~ 100 ms^{-1}) [...] With no exceptions, dust in comet tails is known to be strongly concentrated toward the orbit plane, so that at transit time the tail appears as a straight, narrow streak of light whose orientation coincides with the projected direction of the orbit plane." [7]

All ridge systems, it will be argued below, derive their unique anatomy from this anomalous two-dimensional tail. It not only shapes planetary surfaces, it does so by delivering sheets of ridge-building materials perpendicular to the surface of the capturing body. This unique landing pattern leaves an imprint as clear as a shoe in wet concrete.

THE "BELLYBAND" OF IAPETUS

The cometary hypothesis has already been applied to a mountain range on one of Saturn's moons. The Planetary Society reports:

"It is the only body in the solar system with a self-defined equator; a startlingly linear ridge of tall mountains (a feature that is casually known as Iapetus' "belly band" exactly girdles its equator). [...] judging from the number of huge impact basins and smaller craters covering Iapetus' surface, there has been little in the way of geologic activity on Iapetus recently." [8] (illustration 10)

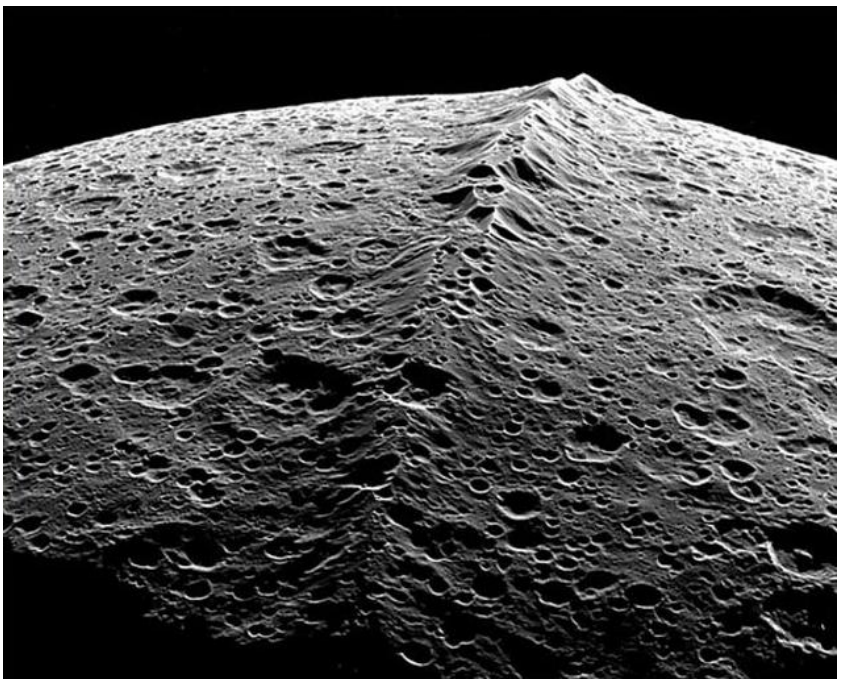

Illustration 10 *Iapetus' "Bellyband", photographed by the Cassini space probe.*

We mention the cratering found adjacent to this formation as we did on the asteroid Eros, for their association with ridge systems is no coincidence. We will be dealing with this further enigma at the conclusion of this paper.

In 2006, Wing-Huen Ip published in *Geophysical Research Letters* what may be the first academically sanctioned extraterrestrial solution to mountain building [9]. He proposed that Iapetus accreted its unusual mountain belt from a ring of orbiting debris. In this article, he provided a schematic of what this might have looked like (illustration 11).

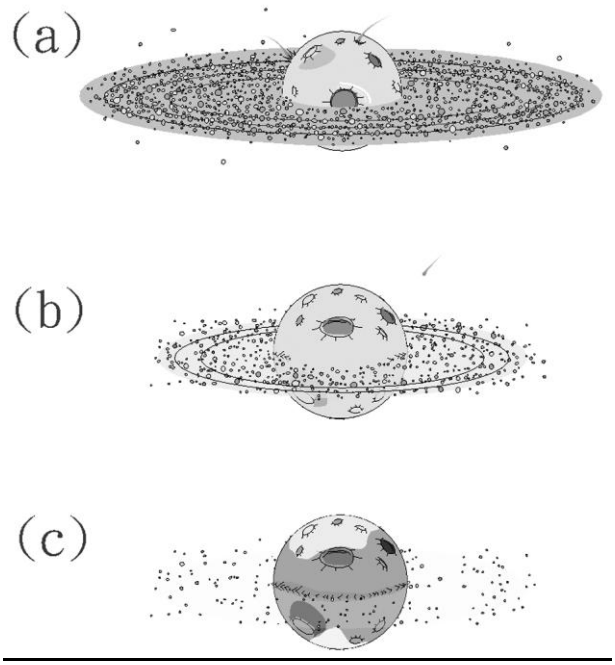

Illustration 11 *Ip's ring accretion hypothesis for explaining the origin of Iapetus' "Bellyband."*

Since this paper will also propose an exogenous solution for all the remaining ridge systems, it is hoped that Ip's publication will suspend the readers disbelief long enough to assess the arguments offered below.

Schematic of a Mountain Belt

At this stage, it will be useful to present a schematic of a mountain belt (illustration 12). This profile is based on the Appalachians, where the system is acknowledged to sit upon the region's bedrock or craton, rather than being 'rooted' in it. This distinction is critical to developing a cometary hypothesis, and was determined empirically through drilling and seismic probes. This discovery will be discussed below.

The lack of any sub-surface tectonic activity effectively excludes any local folding hypothesis.

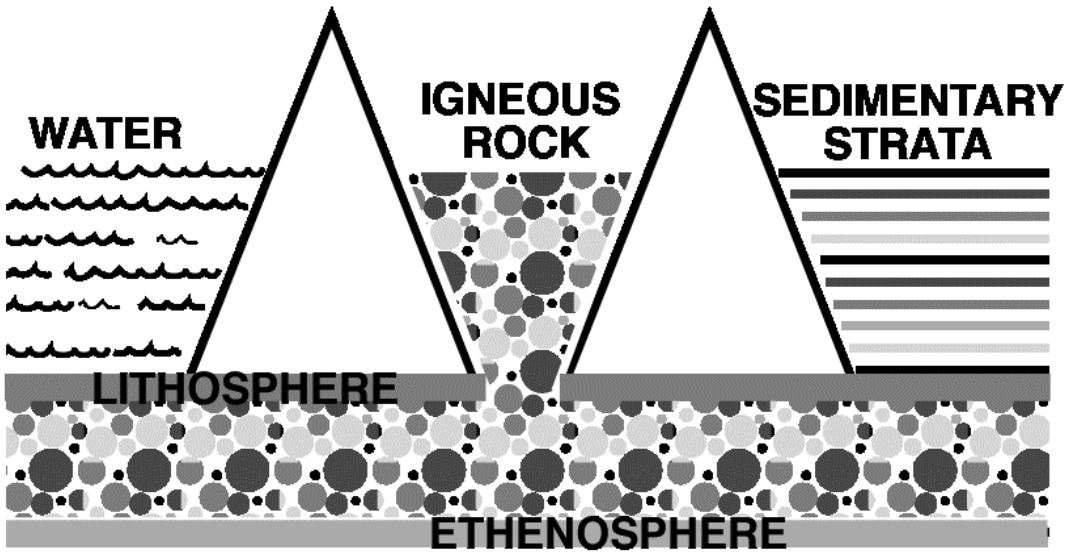

Illustration 12 *Typical basin and range topography.*

Essential Character of a Mountain Belt

A mountain belt contains three essential features.

The first is a chain of discontinuous ridges with an asymmetric triangular profile. This element is what is normally called a mountain range or chain. The asymmetry, not shown in the above schematic (illustration 12), is created by an escarpment or cliff-like face. The shallow side of the ridge is sometimes overlapped by the neighbouring line of ridges. (The ridges are represented in this illustration by triangles. The ridge interiors, unlike the adjacent layered sediments, are unsorted and fossil-free.)

The second feature, less spectacular but greater in volume and economic importance, is the layers of stratified sediments containing fossils. Coalfields are an example of these sedimentary strata found within and adjacent to the ridge system. These strata taper off as they move away from the ridge axes. The strata closest to the ridge axis tend to be disturbed due to a local shearing effect. Some are tilted so greatly (illustrations 13

and 14) that it is suspected that complete sections have actually flipped over. The strata containing the coal seams of the Appalachians, for instance, though originally laid down horizontally dip at angles of up to 50°. The exogenous source of coal is dealt with in a separate publication [10]. Outside the mountain belts, however, strata tend to resume their original horizontal orientation as they move away from the mountain belt axis.

Because all ridge systems are discontinuous and contain gaps, the sedimentary layers, which were deposited by flowing waters, surround each ridge. In other words, the pattern of the entire original deposition of sediments is much like a long lake or estuary, populated by an island chain.

The third element of a mountain belt is the result of magma expelled from mountain-related tears, which create cone volcanoes and larger pools of extruded magma. Some geologists believe that the distortion caused by the extension or contraction of the crust creates tears through which magma pours. Others hold that it is the magma itself that forces its way through the surface. There is a common conviction, however, that mountains, earthquakes and volcanic activity are intimately connected.

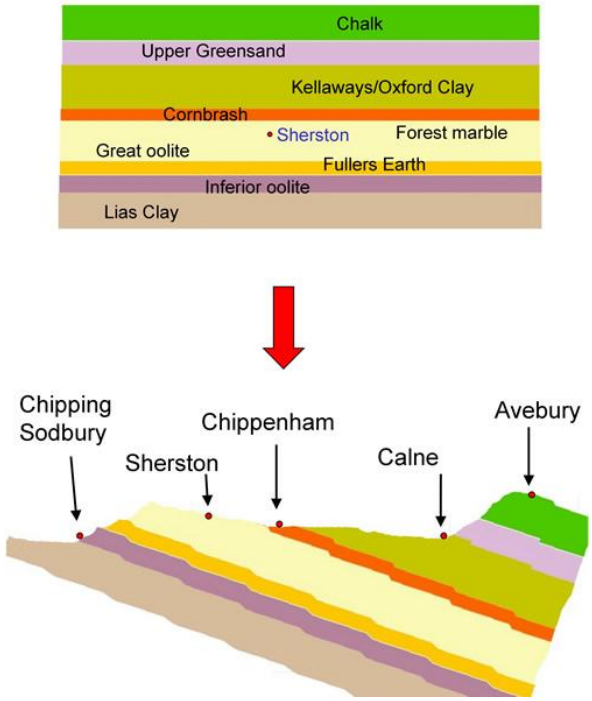

Illustration 13 *Rock strata in North Wiltshire. The rocks were originally laid down horizontally (top) and, after tilting and erosion, gave rise to the present landscape (bottom). Diagram not to scale and vertical scale greatly exaggerated.*

Illustration 14 *Tilted sedimentary layers like these near Joggins, Nova Scotia indicate crustal deformation after the sediment was deposited.*

As will be discussed in further detail below, this igneous union of mountain belt and crust effectively lock the mountain belt to the crust below. This condition should impose a constraint on any attempt to move these sedimentary structures laterally without direct evidence of this motion.

PART TWO: THE RIBBON/RIDGE EQUATION

THE RIBBON/JET CONNECTION

The first time astronomers pierced the dust and gasses enshrouding a comet's nucleus occurred when the Giotto space probe was sent out to greet Halley's Comet in 1986 [11]. One of the surprises was jets ejecting debris from 16 isolated points on the sunward surface of Halley's rotating nucleus (illustration 15). These jets appear to be the source of the number 1 and 2 type tails (illustration 16).

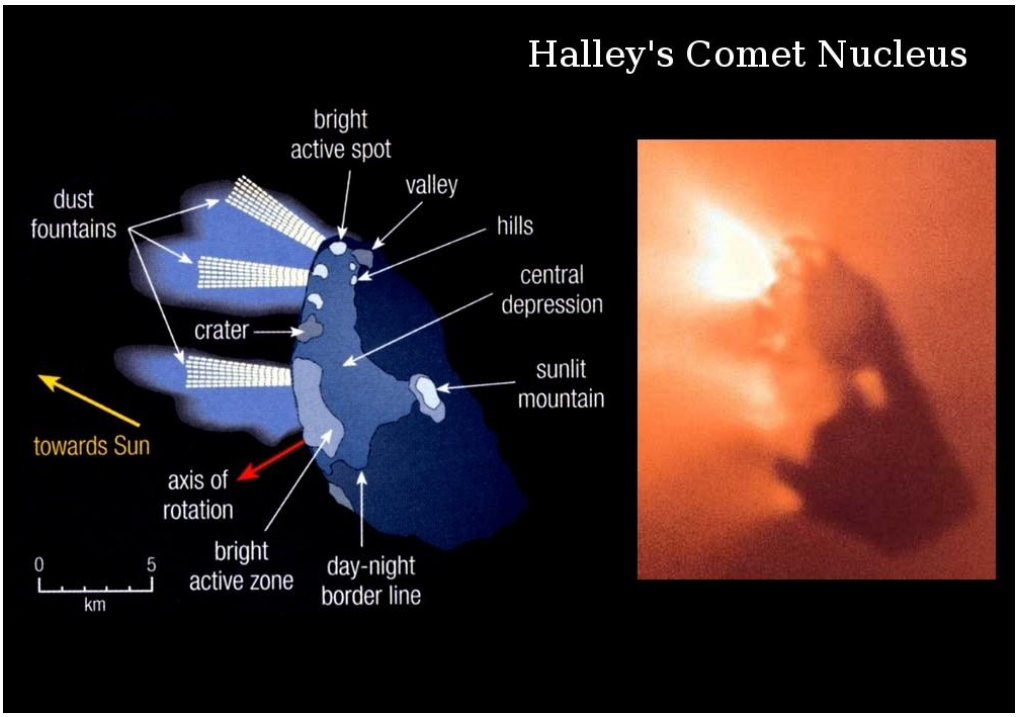

Illustration 15 *Image and labelled schematic of the nucleus of Comet Halley.*

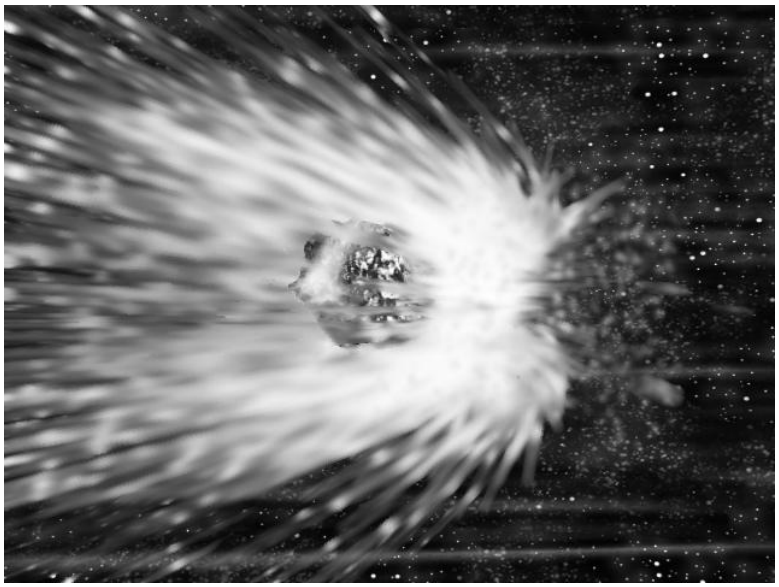

Illustration 16 *Artistic rendition of a cometary nucleus and its jets. The gas and dust particles will be forced by the solar wind and solar radiation pressure, respectively, into an anti-solar direction with respect to the nucleus (to the left of the image). The larger particles, which will form the debris tail, are affected solely by solar gravitation and so will continue in an orbit in a sunward direction (to the right of the image), ahead of the nucleus.*

Further observations, made during periodic comet flare-ups, have determined that the finer particulate matter carried by the type 2 tail – less than one micron in diameter – fragment and subsequently organize themselves into discrete parallel bands called stria [12].

Central to this paper's earth-building thesis is the claim that the fragmentation and subsequent band-forming process observed acting on type 2 tails acts on the heavier ejecta in the debris tail as well. In other words, all cometary debris is divided into three streams: light gases and fine dust which are blown back into the type 1 and 2 tails, respectively, in the anti-solar direction, while the heavier debris continues towards the attracting body, periodically disintegrating and subsequently forming into parallel sets of bands. These 'synchronic bands' will be henceforth called ribbons to distinguish them from striae.

Falling Ribbons

It will be argued that each jet forms a discrete ribbon of debris. Each ribbon, heavily laden with debris from periodic flare-ups, following the same orbit as the main nucleus, is eventually captured and laid down as a single ridge element. When the comet's nucleus is less than 200 kilometres in diameter, it tends to split [13], its many fragments producing great meteor storms which lay down the thousands of ridge elements called eskers and drumlins [2].

Mountain-building comets, on the other hand, tend to retain their planet-sized nuclei intact, laying down much fewer jets of monumental mass.

Capturing Mountains

The capture of a mountain belt has as a consequence the formation of a ring around the capturing primary. First, a segment is cut out of a comets debris tail by the gravitational force of the capturing body. Then, the captured segment is again divided. The leading part ultimately forms a classical Saturn-like ring.

This process begins with the primary capturing a ring arc. These captured bodies have been observed to be circling Saturn (illustration 17), Uranus and Neptune. These partial rings eventually close, become circularized and finally, like most short period comets, move down to the capturing body's equator.

The dynamics producing these rings are poorly understood and a full blown ring has never been observed, but the tendency for ring arcs and other elliptical rings tilted to the primary's equator have been observed and recorded.

The trailing elements of the captured segment, more powerfully drawn down gravitationally towards the capturing body, form the minor and major ridge systems (illustration 18).

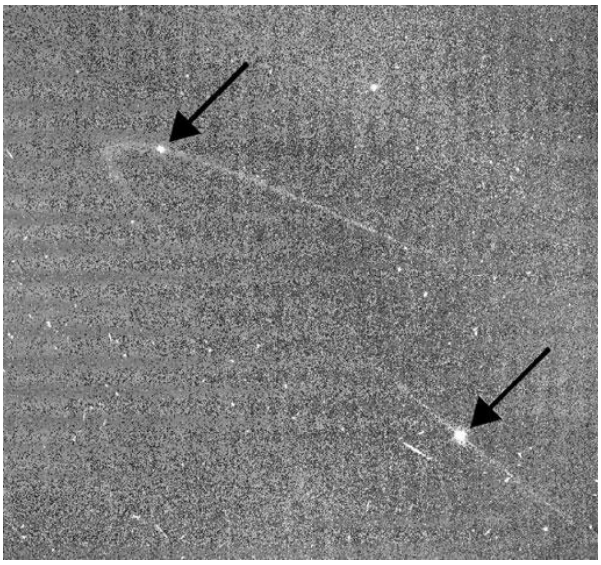

Illustration 17 *Cassini image of ring arcs around Saturn.*

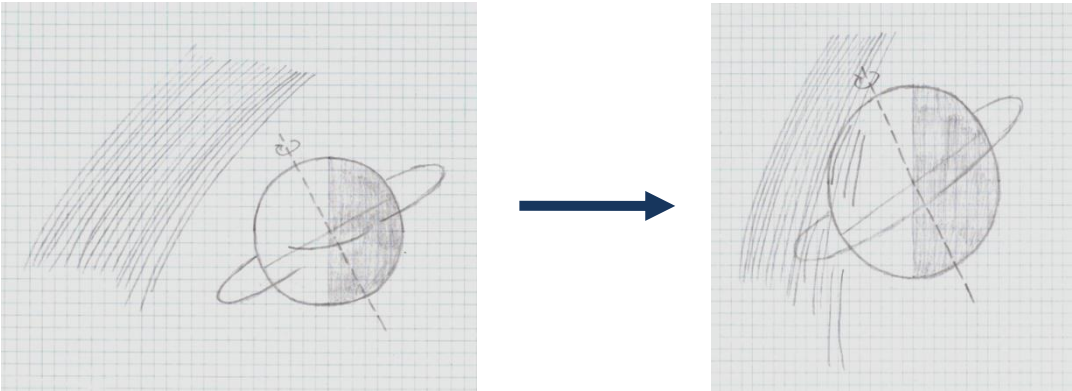

Illustration 18 *Schematic showing the accretion of a set of ribbons and the subsequent formation of ridge elements as well as a ring around the earth.*

MOUNTAIN RIDGE FORMATION

The triangulated profile: The orientation of each flat band, landing perpendicular to the earth's surface, makes it inevitable that each ribbon of debris would land like a dropping sheet or curtain. The two-dimensional ribbon profile would concentrate the falling debris along an advancing narrow line, ensuring a rising ridge profile. Each impacting particle exceeding its angle of repose would slide down the sides of the rising ridge.

Variation of ridge height and width: The surface velocity of a rotating planet increases in linear velocity from pole to equator. This condition is demonstrated in the Appalachians, for their ridges flatten and widen along with their adjacent valleys as they move towards the equator.

Gaps and saddles: The discontinuous nature of each ribbon, which results from random debris outbursts from individual jets, will create a gap or saddle between each accreted ridge, allowing for rivers and animal life to pass through these ridge systems.

THE OPENING ARGUMENT

So far, we have drawn the following points in favour of an exogenous source for mountain belts and their adjacent sedimentary strata.

First and foremost, we have contended that their presence on all solar system surfaces may be explained by the unique manner in which cometary debris is ejected and ultimately deployed by capturing bodies. We have also suggested that present theories for the source and deposition of large and small scale ridge systems are both contradictory and unsettled.

In the following pages further evidence will be added linking cometary debris more securely to structural features common to all ridge systems.

MOUNTAIN BELTS AND TOPOGRAPHY

Prior to the exploration of the ocean depths in the 19th century, Mountain belts were believed to be primarily a land feature. It did not occur to natural philosophers that the great ridge systems that determine the contours of continents and the entire shape of large islands such as Iceland, Japan and the Philippines, were the emerging elements of a mountain belt system, thousands of kilometres in extent.

Despite the wide range and direction of mountain belts, only two major systems exist. The first is the circum-Pacific belt, which rings the Pacific Ocean, stretching over 50,000 kilometres from South America through North America, across Japan and eastern Asia, into the south Pacific. The second major mountain belt forms the Eurasian-Indonesian belt that starts in the western part of Europe and northern Africa, across the Alps in Europe, into the Near East and eventually to the Himalayas.

THE APPALACHIANS

This paper will focus primarily on the Appalachian mountain belt (illustration 19). This system contains the typical suite of rock features: semi-parallel ridges, adjacent fossiliferous strata and pools of congealed igneous rock. The belt runs from Newfoundland, Canada to Alabama, in the southern United States. It is one of the best-explored mountain belts in the world.

Illustration 19 *Aerial photograph of Appalachian mountain ridges and valleys taken near Bristol, Tennessee.*

A Rock Monopoly

The great rock pile of the Appalachian mountain belt represents virtually all the topography in this region. In the 1850's, the Iowa state survey noted that "Although the Palaeozoic formations persist across much of the United States, the total section is much thicker in the Appalachians (12,000 ft) than in the central part of the country (1,200 ft)." [14]

In light of this paper's subject, the great concentration of rock volume in one geographical area is fairly obvious. Less obvious, but equally significant for geology, is the fact that virtually all the rock in this region comes from the first stage of life on earth – the Palaeozoic – and approximately 80% of it is represented by contiguous layers and formations of non-igneous rock.

This great contrast in rock proportion is made more significant by its uniformity in time. This unusual circumstance appears to be common to all mountain belts. The mountainous region in the western part of North America, for instance, is identified with the middle period of life on earth – The Mesozoic. Each of these mountain belts belongs to one of only two major landform systems.

If the cometary hypothesis for the origin of mountain belts is correct, the outcome for conventional dating systems could not be more dramatic. An exogenetic hypothesis suggests that there were, excepting the most recent stage of mountain development – the Cenozoic –, only two major radiations of life on earth, and they both took place over a period of hours.

Mountain Belts and Evolution

The appearance and spread of new species have been associated with evolving mountain ranges. In examining the explosion of new life in the Palaeozoic era, the authors of a 1996 article in the *American Scientist* stated "The Ordovician radiation also

coincided with a period when mountains were actively being forged throughout the world". The authors conclude, "This suggests that an enriched mosaic of habitats, a possible increase in nutrients and changing substrates associated with mountain-building might have played a part in the evolutionary story." [15]

So far, we are faced with two facts: (1) the rocks that dominate the earth's surface are found on all visible surfaces in the solar system; (2) they are also highly concentrated in time and space. These facts suggest that mountain belts have a common origin.

A solution to the origin of the Appalachian mountain belt is therefore likely to shed light on the evolution of continental topography as a whole and perhaps offer insight into the evolution of new life.

ENDOGENY CHALLENGED

If planets acquire most of their surface through extraterrestrial accretion, then many of the assumptions underpinning geological theory need reconsideration. Perhaps the most important of these assumptions is the declaration found in geological texts that the evolution of the earth's crust and its dependant life forms can only be understood by slowing down critical events to an immeasurable pace. A typical example of this is found in a current proposal for a geology course: "The history of the Earth comes from the book of rocks that is otherwise known as the Geologic Record. In terms of a human life span, the Earth does not appear to change in any significant way. The Earth does indeed change, but the usual pace of change is so slow that it is imperceptible."

This dictum, now called 'Deep Time', however, would be clearly impractical on a planet where global landscapes and biospheres may be acquired within hours.

Creating an entire mountain belt containing hundreds of layers of rock, clay, coal and other minerals, according to present theory, calls for the erosion of entire mountain ranges, the growth and death of hundreds of forests, and the advance and retreat of dozens of marine environments. It does not take a trained geologist to believe that thousands, if not millions of years would be required to complete this process. This belief, however, is based on an unstated and untested premise – that most of this planet's solid surface is derived from the earth's interior.

EXOGENY IS NOT CATASTROPHISM

An exogenetic explanation for the formation of the earth's crust has never been contemplated by the secular western mind. From Aristotle and Plato to Ignatius Donnelly, Immanuel Velikovsky and Carl Sagan, extraterrestrial encounters have focused mainly on the destruction of the physical environment and extirpation of existing species.

Paleontological evidence suggests, however, that our biosphere has not only survived, but has been renewed and diversified through a number of distinct global upheavals [15].

The current rationale for this surprising finding is that these catastrophes wiped out so many species, that large environmental gaps became available for new life to evolve. A dark barren planet, however, is scarcely an environment for an explosion of new life.

A more interesting hypothesis might be constructed around a planet that has acquired copious volumes of hydrocarbon-rich materials, concentrated in relatively small, well-defined areas of global surfaces.

OVERNIGHT MOUNTAIN BELTS

The rapid extra-terrestrial acquisition of the Appalachian mountain belt would scarcely be a peaceful event. There would be widespread death and destruction from volcanic eruptions, giant tides and direct impact. Needless to say, these events do not support uniformitarian theory but neither do they support present catastrophist ideas.

Impacting meteors cannot, by themselves, trigger the rapid development of new species, nor explain the origins of mountain belts. The connection between the earth's capture of novel crustal materials and the rapid evolution of its biosphere is not the subject of this particular paper. Nevertheless, rapidly acquired mountain belts appear to provide new approaches to the enigma of macroevolution.

THE WORLD OF ROCK

The material we will be discussing below is rock, which geologists define as "a mineral matter of variable composition, consolidated or unconsolidated, assembled in masses or considerable quantities in nature." [16] So variable is the content of rock that the main categorization of the substance is by particle size, rather than chemical composition. The smallest category of rock is clay and the largest is boulder. Contributing to the difficulty of finding more sophisticated methods of categorizing rock is the difficulty in tracing its origins.

Flint, one of the most respected geologists of the twentieth century stated: "It is clear that the interpretation of upstream paleo-geology from sandstone petrology is not straightforward even when the sandstone contains pieces of the source rock itself. That is, we have been concerned with the ultimate sources of the grains. However sedimentary rocks cover two thirds of the continental surfaces. Not by metamorphic and igneous rock. If we are to construct an accurate paleo-geographic map of the Devonian or Jurassic period we will have to determine which of the sand grains are coming directly from igneous or metamorphic sources and which are being released from older sedimentary rock."

The crucial question of the origin of non-igneous rocks, as will be seen below, is still unsolved. Both Flint and his contemporaries, however, were clear on one issue: that virtually all categories of rock have originated from within the earth. Since the core thesis of this paper is diametrically opposed to this untested assumption, it will be necessary to define our geological terms more closely.

CATEGORIZING ROCK

Flint, like most geologists divided the earth's rocks into three categories: sedimentary, metamorphic and igneous.

WHAT IS SEDIMENT?

The word sediment comes from the Latin *sedimentum*, meaning 'that which is settled'. Sediment originates from wind, ice and water-borne particles, and ends up in easily identifiable layers, usually containing fossils.

Most sediment is considered to be the product of weathering (the slow breakdown of sedimentary and igneous rock), principally by chemical erosion. This process is presently observed in such diverse phenomena as the leaching of Hawaiian lavas by lichens, the hollowing of limestone caves by organic acids and the erosion of Egyptian monuments by damp desert sands.

There are some problems with the definition of sedimentary rock. One of the earth's greatest topographical features – mountain ridges – though classified as sedimentary, show no signs of alluvial transport. Their interiors are fossil-free, and their particulates are unstratified and unsorted. Since I claim that these features are the direct product of a comet's landing pattern, I would prefer to call this category of rock non-igneous. By the same token, metamorphic rock, which is acknowledged to be a mix of igneous and sedimentary rocks, processed by a variety of secondary events, I propose to also call non-igneous. This slight change in categories allows the division of the earth's rocks into its alleged source rock – igneous rock – and its eventual product – non-igneous rock.

THE EARTH'S SHELL AND TOPOGRAPHY

Since the cometary hypothesis claims a clear demarcation between cometary debris, which is surficial, and the earth's shell, presumably made up of congealed magma, all references to the lithosphere or crust in this paper are intended to describe the original solid, semi-spherical surface upon which the earth's topography rests.

MOUNTAINS, EARTHQUAKES, VOLCANOES AND NON-IGNEOUS ROCKS

Present geological theory holds that sediments are derived from lavas issuing from breaks in the earth's crust. This confines their entrance to the upper world to more than 500 active volcanoes. The United States Geological Survey considers volcanoes active if they have erupted at least once within recorded history. The Survey goes on, "Volcanoes tend to cluster along narrow mountainous belts where folding and fracturing of the rocks provide channelways to the surface for the escape of magma. Significantly, major earthquakes also occur along these belts, indicating that volcanism and seismic activity are often closely related, responding to the same dynamic Earth forces." [17]

The relationship of earthquakes to volcanic eruptions was clear, even to the Greeks and the Romans. What is less clear is how these great belts of rocks originated and why the magma from breaks in the local crust and lavas from adjacent volcanoes were expelled from these particular locations.

Although there are no active volcanoes in the Appalachians, it seems obvious that the crust was fractured in many places along the mountain belt in the remote past. On the other hand, there is no evidence that the Appalachians were ever folded. The folding hypothesis was abandoned when drilling and seismic data proved the Appalachians rested upon and not within the crust [18]. Folding theory has now been supplanted by another hypothesis; that the belts were moved from one remote production zone to their present resting place. Both folding and mountain-moving theories will be discussed in more detail below, but it is sufficient to indicate the problems the latest 'allochthonous' theory brings in its wake. It assumes that an entire mountain belt moved intact, overland, without producing any breaks in the crust. Then these ridge systems stopped, apparently for a long stay, where, coincidently, upwelling magma was waiting to weaken and break through the crust. Aside from this improbability the theory assumes that the mountains have found their final resting place. Yet breaks in the earth's crust are only detected in mountain belt environments, suggesting that the act of creating mountain belts and their magma extruding fractures has occurred only during their lifetimes.

LOOKING UP

The latest theory of the Appalachian orogeny is consistent, in one critical issue, with an exogenous theory of mountain building. Both theories negate an endogenous origin for mountain belts. The question now is, was the delivery of mountain-building materials overland or overhead?

The cometary model immediately delivers the required weight of cometary debris by laying down the ridges and sediments of a mountain belt. The periphery of these great ridges combined with the build-up of adjacent sediments would create an awesome shearing stress, rupturing the lithosphere – allowing magma to pour forth and create volcanoes and great pools of igneous rock.

The existence of volcanoes and earthquakes concentrated around mountain belts is therefore no coincidence; neither is it a coincidence that the same fractures and volcanoes are not found elsewhere. They are the consequence of a direct, one-time force exerted on the local bedrock.

THE CHEMICAL DISPARITY BETWEEN IGNEOUS AND NON-IGNEOUS ROCK

Perhaps the most critical test of a cometary hypothesis would be a different chemical and physical signature for the cometary debris and the magmas rising subsequent to the crustal fractures produced by the deposition of a mountain belt.

Endogenetic theory necessarily holds that there must be a clear and direct association between pools of congealed igneous rock and the great layers of mountain ranges and the sediments surrounding them. It is assumed by all endogenic theory that sediments are the eroded remnants of mountain belts.

The cometary hypothesis, on the other hand, holds that mountain belt sediments are 'loose' cometary debris, incorporated into ridge systems and sedimentary strata.

"A PENULTIMATE SILICATE FROTH": THE ALIEN CRUST

In an article published by Skinner in *American Scientist* [19], the author comments on the physical contrast to be found in the earth's sediments and the magmas that presumably created them: "Crustal rocks appear literally to be a penultimate silicate froth of the most uncommon terrestrial elements [...]." The writer concludes, "Because the earth and oceans and air are extreme distillates and fractionates of the average original earth and very unlike it in composition and origin, it is obviously risky, if not misleading, to infer that superficial studies tell much of what we must know of time in the earth."

In the 40 years or so since Skinner made this statement, drilling ships such as the Glomar Challenger and a variety of indirect techniques, primarily seismic, have been employed to probe the depths of our undersea world. In this age of plate tectonics, the search is focused on locating the course of circulating magmas responsible for determining the course of descending slabs of old ocean bottom and the slowly emerging slabs of new plates.

In a recent international conference, entitled "Transport of Materials in the Dynamic Earth" (2001), more intensive isotopic studies underscored Skinner's appreciation of the earth's "penultimate silicate froth."

In a leading paper, the authors reported their study comparing the volcanic radioactive elements found in Samoan volcanic rocks with continental (terrigenous) rocks. [20]

The investigators believed that "[The mantle plumes] may provide our most direct sampling of the deep mantle, and this distinctive chemistry is conventionally ascribed to recycling of ancient lithosphere containing a terrigenous sediment component." In other words, the authors were attempting to link sub-crustal magmas with continental rocks.

They reported "[…] No model has as yet satisfactorily accounted for many of the puzzling geochemical characteristics of hotspots."

The authors carefully traced the materials scraped off the overlying terrain in attempting to match magma and continental sediments. "By comparing the geochemical character of basalts from Ta'u Island, Samoa, which are the least enriched [in radioactive isotopes] of Samoan basalts [...] with the most-enriched material, from Malumalu Seamount [...] we are able to characterize the trace-element patterns of the 'enrichment' [the mixed molten materials]; what is noteworthy is the very large negative [Page 23] Ti [titanium] anomaly in the enriched component, indeed suggestive of a terrigenous sediment component." The authors concluded "However, the lack of Pb [lead], Nb [niobium], and Ta [tantalum] anomalies, and the negative Ba [barium] anomaly, are difficult to reconcile with a terrigenous pedigree for the enriched component. One can simply assert that chemical processing during subduction has erased the continental fingerprint."

What makes these conclusions more relevant to a cometary hypothesis is the lack of success in chemically matching volcanic lavas to the contiguous sediments.

The Case for Travelling Mountain Belts

In developing their basic approach to orogeny, 19th century geologists took two basic approaches.

One faction believed that long narrow basins gradually filled with sediments. The weight of these sediments drew the formation beneath the earth's crust. The heat and pressure of the earth's interior converted the loose debris into solid rock and, eventually, the ridges emerged fully formed as mountains.

A second faction, using the model of a cooling, previously molten earth, argued the earth's crust developed corrugations while cooling, likes a wizened fruit.

Both explanations assumed mountains to be local, relatively static features, their flanks or roots embedded in the lithosphere.

Recent drilling and seismic investigations derived from the Appalachians as mentioned above [18], however, found no evidence to support either theory. In no place investigated in the entire mountain belt is there any sign of a rooting of the mountain

ridge system into the continental bedrock. This caused a revolution in orogenetic theory.

"ONE CAN STILL MARVEL AT THE RECENT CHANGE OF PARADIGMS …"

The revolutionary nature of this discovery was noted in a special edition put out by the Geological Society of America on the history of Appalachian orogenetic theory [18]:

"One can still marvel at the recent change of paradigms […] The Appalachian mountain system, the 'Eastern Overthrust Belt,' The Piedmont, the Carolina slate belt and other crystalline terrains [...] were once thought (and not that long ago) to be firmly rooted in the continental crust, an integral part of the Laurentian craton (a relatively rigid and immobile region of continental portions of the earth's crust). The probability, or even possibility, that these terrains have travelled 250 km or more on horizontal faults would have seemed fanciful, even as little as 25 years ago. That the Charlotte, the Kiokee, or the Raleigh belts are micro-continents that may have travelled hundreds or even thousands of kilometres to 'dock' against the Laurentian craton would have been scoffed at as another variation of the then largely discredited theory of continental drift."

Moving entire mountain ranges, row on row, hundreds of kilometres, may seem fanciful, but there is little choice for geologists wedded, for hundreds of years, to endogeny. But the alternative of mountains from the sky, to layman and scientist alike, seems even more fanciful. The evidence for this hypothesis, however, is compelling.

MOUNTAIN-MOVING PROBLEMS

While geologists still contend with such critical issues as the necessary locomotion required for moving mountains, more fundamental problems must be faced, the first being – if mountain belts move, why do they stop over lithospheric fractures? It must be assumed that their mass has not changed; yet the damage associated with their present resting place appears permanent with volcanoes and magma spouting tears located along their path. One must ask what event made them stop, for what sees permanent

rest? Also there is the question of the building up of sediments adjacent to mountain ridges. These deep layers of fossil-bearing sediments seem to be a local phenomenon, apparently related to the erosion of ridges themselves. All the non-igneous elements of the Appalachians belong to the same Palaeozoic era. If so, these deep layers of sediments must have travelled along with the volcanoes and ridge elements?

Aside from local tilting of adjacent sedimentary strata, the intermountain sediments and deposits of igneous rock of the Appalachians appear undisturbed. It is unlikely that they would have travelled hundreds of kilometers without demonstrating significant disturbance. Moreover, the entire Appalachian mountain belt appears to be a rather static structure. In the exploration of the origins of sediments dealt with below, evidence will be offered to suggest that the Appalachians and other mountain belts have not eroded to any significant degree.

The present positioning of mountain belts over breaks in the earth's crust, along with the relatively undisturbed position of volcanoes, lava traps and stacked inter-mountain sediments, represents one of a number of problems facing a credible theory of laterally moving mountain belts.

Mountain Folding

The Appalachians, the most closely examined of mountain belts, appear to be the only continental mountain belts that have been proved to be surficial features. What of the others?

Most orogenic theories deal with the distortion of the crust by crustal extension or contraction, presumably pushed and pulled by lateral plate-tectonic forces. This implies that the underlying bedrock, whether igneous or sedimentary, was incorporated into the final structure.

Charles Lyell, the leading geologist of the 19th century, believed, along with many of his colleagues, that the pressure of molten rock was the motive force for uplift. They therefore deduced that cooled molten magma lay at the heart of great mountain ridges. The 'folding' phenomenon was due to the doming of the overlying sedimentary strata in response to locally rising magma. Charles Lyell, on taking a good look at the peaks of

mountain ranges, was somewhat puzzled by their triangulated or 'hinged' profile. They should have been more rounded, he reasoned, but took the thought no further. Well before the end of the 19th century, a consensus arose that mountain ridge interiors were sedimentary, and the magmatic intrusion theory passed into disuse until the age of plate-tectonics.

The rising magma theory was generally superseded by Eli de Beaumont, a brilliant French cartographer who brought in the concept of mountain belts as wizened fruit. This approach was derived from the cosmological theory that the earth, as a cooling molten orb, started its cooling process from the outside in, allowing the crust to contract. The contraction placed local tangential pressures on the crust, which rose as mountain ridges. This in turn was criticised on two important grounds.

The first was strictly mathematical. In a mountain belt such as the Appalachians, there was simply not enough crustal fabric to create the folds. Assuming a conservative equilateral triangle for a typical ridge profile, a ridge would consume two lengths of crustal fabric for each lateral length moved. The crust simply ran out of available fabric at an early stage of folding. Moreover, the molten condition of sub-crustal rock, suggested that the contraction would be spread around the globe evenly.

Compounding this difficulty, mountain ridges show no indication that they were once covered by layered sediments. Their interiors are unsorted and fossil-free, and there is no indication of other conventional sorting or stratification. Each ridge should show a continuity of surface characteristics, and this is simply not the case. In other words, the surface layers of mountain ridges should display the same stratification as the flat lands adjacent to them, but it does not exist. The only explanation offered is that the evidence of fossilization and stratification was lost in the chaos of formation. The disappearance of the evidence required for the theory, by the very phenomenon we are trying to critically examine, is indeed unfortunate.

But this explanation is particularly difficult to accept due to the excellent preservation of the sediments arrayed adjacent to mountain ridge systems that presumably either moved with them or over them.

THE PERSISTENCE OF FOLDING

Despite the general discomfort with mountain building that is dependent on ideas of upwelling magma and compressive folding, geologist persist in using dubious ideas in orogenetic writing. The reason is obvious; there are just so many explanations available in an endogenetic model. After a suitable number of years, old questionable theories are recycled to explain the birth and death of mountain ridges.

PART THREE: LOOKING OVERHEAD

Cometary dynamics is still an obscure science, but recent observations have confirmed that many comets tend to flare-up and lose significant portions of their mass as they approach and retreat from their primaries [21] [22] [23]. This is most frequently observed in their passage around the Sun. In 1994, however, the remaining 15 of the original 21 fragments of Comet Shoemaker-Levy 9 were captured and accreted by Jupiter [24] (illustration 20). This event suggested that comets show the same disintegration pattern when captured by a planet as they do when rounding the Sun.

There is no clear understanding of when and why comets flare-up, split and rapidly lose their substance [13]. The concept of Roche's limit is sometimes used but there is no consensus*. Influenced by the current model of comets as frail and insubstantial collections of ice and dust, many astronomers believe that competing gravitational forces pull a comet's insubstantial nucleus apart as it nears its primary. This theory, fabricated to account for a comet's anomalous flare-ups deep in outer space, is becoming suspect as we are able to look more closely at the surfaces of cometary nuclei. We find their appearance very similar to other bodies in the solar system. Whatever the explanation for a comet's shrinkage, it would take a loss of less than .01% of the mass of a Venus-sized nucleus to provide our planet with its great mountain belts. Comets have been known to lose even greater percentages of their mass over one perihelion approach [25].

---

* From "Split Comets" by Hermann Boehnhardt [13]: "Several fragmentation mechanisms are used to explain the splitting of cometary nuclei. Thus far, the success of these scenarios in the understanding of these events is limited, presumably since (1) the most important parameters of comet nuclei (such as internal structure, nucleus/surface stratification, material types, tensile and shear strengths, size, and rotation) used in these models are not at all or not very well known, and (2) the available observations do not constrain well the actual event sequence and the physical properties of the parent and daughter components of split comets. Not surprisingly, only for one split comet, D/1993 F2 (Shoemaker-Levy 9), do modelers seem to agree on the fragmentation scenario (i.e., tidal splitting close to Jupiter), although with significant differences in the details of interpretation and conclusion."

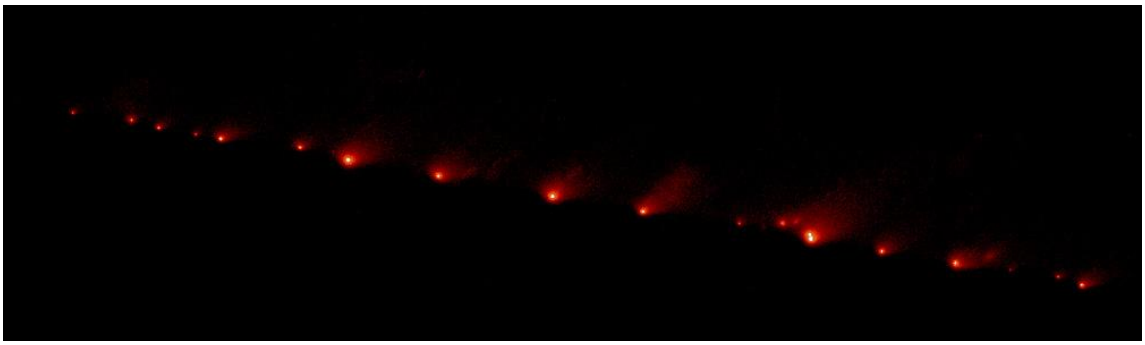

Illustration 20 *The 21 "pearls on a string" of Shoemaker-Levy 9 on their approach to Jupiter in 1994.*

THE COMET AS COSMIC MILL

The rapid rate of cometary dissolution is a poorly understood mechanism. The "explosive" process can take place at any point on the body's elliptical orbit and has been observed to occur as far as 50 AU from perihelion. [13] [26]

THE VALUE OF MINOR RIDGE SYSTEMS

Smaller scale ridge systems are an important model for establishing an exogenic model for planetary topography. Esker and drumlin ridges are not massive enough to shear the earth's crust. Though dramatically lower in total mass, their laydown takes the form of a great meteor storm composed of tens of thousands of debris ribbons [2]. But their smaller scale has provided an easily accessible, well preserved memorial of the event that laid them down. Locked in their rocky interiors and strewn about their sides is a clear narrative of their journey from jet to ground.

How these ridges of sand and gravel, great and small, turn to rock seemingly overnight will also be discussed below.

ESTABLISHING RIBBONS

We began the argument for exogeny by tracing the unusual profile and organization of ridge formations to the thin sheet of debris ejected from cometary nuclei, and followed it to its final unique perpendicular landing pattern.

Of equal importance in establishing exogeny is proving the existence of individual ribbons of cometary debris and the order in which particles in each ribbon are organized.

The evidence supporting this contention comes from the unique structure of glacial land forms. Not only are they made up of materials alien to the earth's interior, the order in which they are organized and the surface condition of each particle, from top to bottom, is directly opposite to the order and condition expected of materials conveyed by either ice or water [2] [27]. This arrangement, with the finest debris found furthest (laterally) from the nucleus, seems at first, fully rational. Theory dictates that the larger than micron sized particles ejected from the nucleus of a comet should be organized, along the comet's orbit, with the most massive particles closest (laterally) to the nucleus. But physical mysteries still remain. Both the thinness of the debris tail as reflected in the width of landed eskers and the ribbons in which they are delivered cannot be easily explained or even definitively observed. This is due to the limitations of present astronomical observation techniques which can detect fluorescing and reflecting micron-sized ejecta, but ironically cannot observe the darker surfaces of metre–sized boulders. Fortunately, the fragmentation pattern and subsequent organization of ejecta into discrete bands has been observed in type 2 dust tails [12].

STRIAE

During periodic cometary flare-ups, astronomers have observed stria – parallel strips of dust in the type 2 dust tail, fragmenting and expanding laterally during "outbursts". This process, takes place simultaneously along the entire length of the affected stria [12].

Kimihiko Nishioka describes this process: "Some big comets showed type II tails with many narrow striae called "synchronic bands," the formation mechanism of which is still unknown. A dynamic model for the formation mechanism of synchronic bands [...] is proposed.

The complex particles [...] disintegrate repeatedly into individual unit particles at various disintegration speeds. Then, these unit particles break up and their fragments are observed as synchronic bands. These fragments continue to disintegrate or sublimate into smaller pieces and finally they become too small to be seen at a certain normalized lifetime.

The structures calculated with this theory fit well the observed shape and orientation of the synchronic bands of Comet West and Comet Seki-Lines." [28]

Zdenek Sekanina et al. have also observed the same process taking place in Comet Hale-Bopp. From early March to mid-April 1998, a series of photographs captured the birth of striae over a 40-day period: "[...] At that time they appeared very weak and confined on the "young" side of the dust tail. During 8 to 18 March 1998, 17 prominent and well defined as well as at least 9 weak to marginal striae could be identified and measured in the processed images." These stria, like the unseen ribbons of the earth-building debris tail, develop laterally and broaden. "The striae became very broad and diffuse in early April 1998 (still present on 8 April s1998). The preliminary analysis showed that the mother grains of the striae dust were release from the nucleus about 40-60 days before perihelion." [29] (illustration 21)

It is this activity, observed in type 2 dust tails, that we contend mirrors the same process that takes place in the debris trails moving towards any capturing body, be it the Sun, Jupiter or our own planet.

The Meteor Storm as Endgame

In attempting to construct a credible model for mountain belt building, it is necessary to understand super swarm production as the termination of a much larger event.

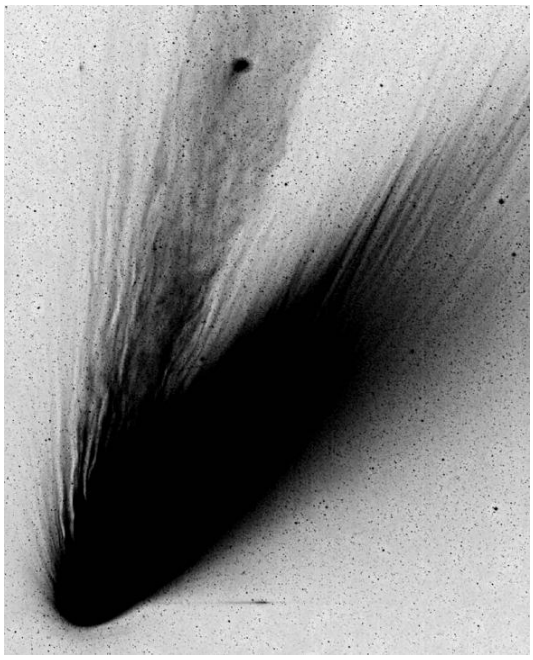

Illustration 21 *From "Split Comets" by Hermann Boehnhardt [13]: "Striated dust tail of Comet C/1995 O1 (Hale-Bopp). In March and April 1996 the diffuse dust tail (right part of the image) of Comet C/1995 O1 (Hale-Bopp) contained many striae. In the image the striae are best visible as narrow straight bands to the outer edge of the dust tail. [...] The prominent structured ion tail points away from the direction of the Sun. [...]"*

The track of the ridges forming super swarms rarely reveal boulders more than a few metres in diameter, and the many craters (called pot holes or kettles) strewn along their paths, both on earth and elsewhere, show no indication of bolide impact. It is necessary to conclude, as in the case of the fragmentation of Comet C/1999 S4 (LINEAR) [13], that the fragments that produce super swarms, are essentially dissociated prior to accretion. This does not appear to be the case for mountain belts. The relatively small number of semi-parallel ridges, suggest that no more than a dozen active ejecta-laden ribbons were captured and accreted during the mountain building episodes.

Ring Tones

Another important line of evidence supporting the structure and order displayed in ridge architecture are found in planetary rings. Only in recent times have they been connected directly to comets, for the 19th century consensus was the view that rings

were primordial, a product of the creative cosmogonal swirl that moulded the nascent sphere. Improved observational techniques began to detect transitional phenomena.

Although we cannot pinpoint the source of each planetary ring, Jupiter, Saturn, Uranus and Neptune all appear to have very thin featureless bands of debris spreading towards their respective equators from the outer edges of their outermost ring. This translucent web of dust, which is called the plateau at Neptune and gossamer at Jupiter, appear to be associated with their moons and mysterious ring arcs. (illustration 17)

Voyager's trip to Saturn disclosed main rings that will one day be compared to a flared-up comet's debris tail. They were "[...] composed of ringlets so numerous that the ring system looks much like a phonograph record, with thousands of thin grooves in it." [30]

It is not clear whether a gossamer web join each of the thousands of ringlets, but recent examination of Saturn's ring gaps has disclosed that thin bands of debris join them. The NASA website reports that "[...] divisions between the rings, once thought to be empty spaces, were now seen to be full of very small fine-grained particles [...] Some ring bands appeared to have sharp outer walls, while others seemed to go on and on."

AMALTHEA AND THEBE

Though the direct creation of planetary rings by comets remains somewhat speculative, two recent observations of the great ringed planets appear to be bringing respectability to the idea.

In the January 1999 edition of *Astronomy*, Tracy Steadier reported: "Galileo imaged Jupiter's faint outer ring, known as the gossamer ring, with remarkable clarity. This ephemeral ring was found by Galileo to be made of two dusty rings of debris. On closer inspection, surprised astronomers also discovered that the rings were trailing from the orbits of two small Jovian moons: Amalthea and Thebe. These satellites orbit Jupiter in paths that tilt slightly relative to the gas giant's waist. In an elegant twist, the vacillating paths of Amalthea and Thebe correspond to the thickness of their sides. 'Since the particles have the same orbit and tilt, they are probably born of the satellites,' says Cornell University astronomer Joseph Burns." [31]

Note again the anomalous ejection of debris precisely along the plane of the orbiting satellites – exactly the motion proposed by McCrosky [3], Maddox [6], Sekanina [7] and others for the disposition of cometary debris.

In May 2009, a group from the Cassini mission to Saturn published "Enceladus: An Active Cryovolcanic Satellite." [32]

"Enceladus is one of the most remarkable satellites in the Solar System [...]" (illustration 22) Most of their attention was focused on the evidence of a substantial ocean, on what should have been a deeply frozen body. They observed plumes, consisting mainly of water being ejected from "jets" located at Enceladus's south pole.

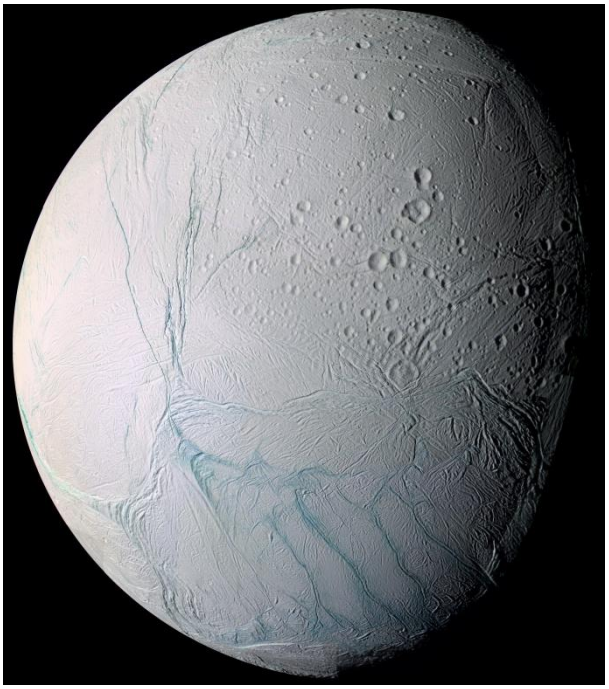

Illustration 22 *Large mosaic of images taken by the Cassini Spacecraft of Saturn's moon Enceladus.*

In the excitement, a reader might be forgiven for missing a most unusual finding on the disposition of this satellite's ejecta, for "The authors concluded that these processes probably provide the dominant source of Saturn's E ring."

The authors, however, failed to mention what mechanism organized the movement of these ejecta from a motion perpendicular to the satellite's orbit to a final home on Saturn's ring plane.

SHOWERS

The capture of the rocky ribbons produced by cometary debris tails may be witnessed on any cloudless night of the year as their particles are ignited by our atmosphere [33] (illustration 23). Less frequently but more impressively, the earth passes through the trail of a comet on its return to the inner solar system, and then the night sky looks similar to the great meteor storms that produced the New Quebec, Keewatin and Gulf of Bothnia super- swarms [2].

Illustration 22 *Leonid meteor shower.*

In establishing an exogenetic origin for super-swarms, it is not necessary to construct statistical models justifying their formation. We witnessed such an event taking place between Comet Shoemaker-Levy 9 and Jupiter in 1994 [24]. As for the frequency of trails of comets passing through the Earth's orbit, it happens at least 11 times a year [33].

Though the era in which these ridge systems were formed is not precisely known, the ceremonials and related sacred texts dealing with ancestral memories of these great meteor showers are extensive and convincing. They are dealt with elsewhere [34] but a particularly vivid and detailed memory of these events was passed down by the Skidee band of the Pawnee nation. Their priests calmed their tribe, who were panicked by the great meteoric shower of 1833 [35], with the explanation that stars may be falling to earth, but the North Star, they assured the tribe, was still in its place, and so the world would not, this time, come to an end.

It should also be noted that this cosmocentric tribe must have seen comets during a much closer approach, for they call comets "feathered stars" and were inveterate meteorite collectors. Their leading priest represented the planet Mars, who was pictured riding on a bed of meteorites.

Immanuel Velikovsky – author of "Worlds in Collision" and the 20th century's leading catastrophist – was certain that the planets Mars and Venus, in a series of near encounters, produced these great meteor storms. While neither holding to nor repudiating these claims, Velikovsky's reconstruction of these great cosmic storms is so astute and colourful, that this excerpt should be reproduced: [36]

"The Terrible Ones

Venus had a tail, considerably shortened since the time it was a comet, but still long enough to give the impression of a hanging flame, or smoke, or attached hair. When Mars clashed with Venus, asteroids, meteorites, and gases were torn from this trailing part, and began a semi-independent existence, some following the orbit of Mars, some other paths.

These swarms of meteorites with their gaseous appendages were newborn comets; flying in bands and taking various shapes, they made an uncanny impression. Those which followed Mars closely looked like a troop following their leader. They also ran along different orbits, grew quickly from small to giant size, and terrorized the peoples of the earth. And when, soon after the impact of Venus and Mars, Mars began to threaten the earth, the new comets, running very close to the earth, added to the terror, continually recalling the hour of peril.

Ares of Homer, going into battle, is accompanied by never resting horrible creatures, Terror, Rout, and Discord. Terror and Rout yoke the gleaming horses of Ares, themselves dreadful beasts, also known by these names; Discord, 'sister and comrade of man-slaying Ares, rageth incessantly; she at the first rears her crest but little, yet thereafter planteth her head in heaven, while her feet tread on earth.'

Similarly, the Babylonians saw the planet Mars-Nergal in the company of demons, and wrote in their hymns to Nergal: 'Great giants, raging demons, with awesome members, run at his right and at his left.' These 'raging demons' are pictured also in the Nergal-Eriskigal poem; they bring pestilence and cause earthquakes.

It appears that the mythological figures of the Furies of the Latins or the Erinyes of the Greeks, with serpents winding about their heads and arms, flashing flame with their eyes, swinging torches around like wheels, grew out of the same prodigies which moved rapidly, changed their forms hourly, and acted violently. The Erinyes traveled in a group, like huntresses or like a 'pack of savage hounds,' but sometimes they appeared to be split into two groups.

To these comets, traveling in bands with Mars or Indra, are dedicated many Vedic hymns, indeed a great part of them. They are called Maruts 'shining like snakes,' 'blazing in their strength,' 'brilliant like fires.'

> O Indra, O strong hero, grant thou glory to us
> with the Maruts, terrible with the terrible ones,
> strong and giver of victory.

And it is said that their 'strength is like the vigor of their father.'

> Your march, O Maruts, appears brilliant. . . .
> We invoke you, the great Maruts,
> the constant wanderers. . . .
> Like the dawn, they uncover the dark nights
> with red rays, the strong ones,
> with their brilliant light,
> as with a sea of milk. . . .
> Streaming down with rushing splendor,
> they have assumed their bright and brilliant color.8

Stones were hurled by these comets.

> You the powerful, who shine with your spears,
> shaking even what is unshakable by strength . . .
> Hurling the stone in the flight! . . .
> All beings are afraid of the Maruts.
>
> May your march be brilliant, O Maruts . . .
> Shining like snakes.
> May that straightforward shaft of yours, O Maruts,
> bounteous givers, be far from us,
> and far the stone which you hurl!"

SPLITTING AND RIBBON-MAKING

The fragmentation of comets appears to be a two phase mechanism designed to systematically reduce all matter to heterogeneous rubble in a cosmic recycling scheme.

When a comet is in full flare-up mode, it is distributing light gases and micron-sized dust into a gigantic torus (donut shaped) cloud called the zodiacal light in one direction and a far greater load of earth-building debris in the other.

It is only in the earth-building debris train, made up of fragments massive enough to follow the path of the main nucleus [4], that the comet undergoes splitting. This poorly understood phenomenon creates a series of mini-comets or cometesimals [13], a process which accelerates the comminution or fragmentation to a point where the mother nucleus is reduced to a series of stacked ribbons.

In other words, each and every fragment in a comet's debris tail, when it splits, functions exactly as the mother body, following its elliptical orbit along the same two-dimensional plane, until the next outburst, at which time the same splitting and concomitant debris production will take place.

The closest view that astronomers have obtained of this activity was the disintegration of a fragment of Comet Schwassmann-Wachmann [37] (illustration 23) during which 154 cometesimals were born: "The fragmentation of the split Comet 73P/Schwassmann-Wachmann 3 B was observed [...] We analyzed the [...] images, detecting no fewer than 154 mini-comets [...] We found that most of these mini-comets were ejected from fragment B by an outburst occurring around 1 April 2006 [...] We found that the radius of these mini-fragments was in the 5- to 108-m range [...]" [38]

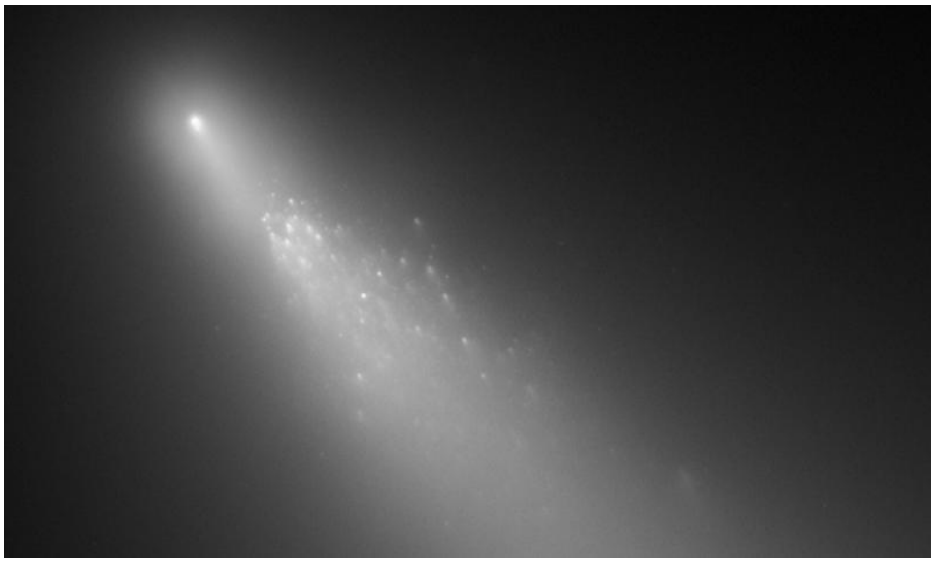

Illustration 22 *Hubble image of the breakup of Schwassmann-Wachmann, April 2006.*

It would not require an overly sophisticated scientific mind to judge the significance of Schwassmann-Wachmann's fully disaggregated fragment B crossing the earth's orbit just after the 2007 flare-up. A 100 m diameter fragment would produce a ten meter high esker approximately 5 km long.

In "Tails of a Recent Comet" [2], the match-up of a comet's debris trail, presumed to be divided into discrete ribbons, was compared to the topography of a mixed swarm of eskers and drumlins in unconsolidated and lithified form. The unique condition and order of the particulates incorporated inside of and strewn about these ridges of sand and gravel were also compared to hypothetical curtains of debris shifted and abraded by our planet's atmosphere, and found to closely match these conditions.

In reviewing this paper more than a decade later, some assumptions concerning the origins of debris tail ribbons were either shaky or wrong*. Nevertheless, the recent space probes of comets and the exploration of Saturn's ring system and satellites by Cassini have strengthened the arguments for an exogenetic origin for earthly and intra-planetary ridge systems.

In the following section dealing with the formation of mountain belts, the arguments developed for minor ridge formation made in the author's previous paper will be repeated only for emphasis. New evidence supporting an exogenetic origin for both minor and major ridge formations will be presented.

MOUNTAINS ARE NOT CONE VOLCANOES

A comparison of mountain building theories must begin by understanding what geologists mean by 'mountains'. The Random House Dictionary definition is closer to that of a cone volcano: "moun·tain (mounÆtn), n. A natural elevation of the earth's surface rising more or less abruptly to a summit, and attaining an altitude greater than that of a hill, usually greater than 2000 ft. (610 m)" [39]

The phrase 'mountain belt' which we mean to be a semi-parallel series of ridges, filled with sediment and volcanic materials – the focus of this paper – is not even found in the same comprehensive dictionary, although 'mountain belt' registered near 5,000 hits on Google.

* The first error was attributing the discontinuity of all ridge systems to the rotation of cometary nuclei. I assumed that all ridges were tied to the production of each active jet on the sunward or primary-facing side of the nucleus. In other words, the 'morning' and 'evening' defined the length of each ridge. It was only when I did the arithmetic that I discovered that a typical cometary day of 11 hours would create a ridge of close to 40 kilometres in length, assuming an average escape velocity of 10 metres per second. This exceeded the average length of esker/drumlins by one order of magnitude. It now seems more appropriate to attribute the discontinuity to sputtering, an electrostatic force suggested for the source of Encelidus's contribution to Saturn's E ring. The second error was confusing the elusive debris tail with the visible type 2 striae-producing tail observed by Nishioka [28] and Sekanina [29].

Mountain building theory, along with its concomitant seismic and volcanic activity, a historically problematic topic, is currently the principle byproduct of the reigning plate-tectonic paradigm.

To be specific, mountain belts, according to present theory, are the product of the collision and separation of plates. Oddly, this disparate set of movements, one plate pushing and the other pulling, is capable of making mountain belts of the same design.

And yet plate tectonics is apparently a system, like life itself, which may only be found on earth.

This is only one of the many problems involved in matching this theory to the evolution of great and small ridge systems found on all terrestrial planets and their satellites. The difficulties with plate tectonics and other endogenic theories will be discussed in more detail below, but it should be clear by this stage that a single cause for all intra-planetary ridge systems deserves serious consideration.

Applying a cometary solution to mountain building brings the weaknesses of endogenetic theories into further relief.

THE NORWOOD ESKERS

On Friday August 21, 2009, the author and a colleague visited one of the last esker formations in Southern Ontario. Though located within a busy quarry run by the Drain Brothers, much of its classic structure remained intact, for the sturdy 15 metre high ridges bore the pylons of Ontario Hydro's high-tension power lines (illustration 23). In the act of mining the gaps between the pylons, the quarrymen revealed the 'smoking gun' of exogeny [2]. Within the base of the core, exposed by the mining, was the layer of sharp-edged sand. Lying on the sand was the gravel, its edges becoming more rounded as the particles rose to the esker's ridge top. Lying near the top of the interior of these formations were large, fully rounded boulders (illustration 24). Adjacent to the formation, quarrymen were excavating several flat-bottomed pits, called pot holes or kettles, stacking the aggregates into heaps according to particle size.

Illustration 23 *Esker near Norwood, Ontario. This formation runs for many kilometers in a north-east direction and is part of the New Quebec super-swarm.*

Illustration 24 *Excavated interior of an esker near Norwood, Ontario. Of particular interest is the increasing particle size and roundedness as one moves from bottom to top. The boulders observed at the base have rolled down from the top during the excavation process.*

In the concluding parts of this paper, the difficulty of ascribing the genesis of these ridges and gravel pits to the action of flood or ice will be discussed. At this stage, a review of the capture and laydown of a Norwood type esker should provide an excellent model for the evolution of its giant forbearers – our earth-girdling mountain belts.

An Esker Is A Naked Drumlin

Before describing the fiery entry of an esker/drumlin swarm, a brief description of the three main ridge types involved is necessary. Although eskers are always in a minority position, they are usually found adjacent to drumlins and their related forms (craig and tails, roche moutonnées (illustration 25), rock drumlins, flutes etc.). And this is the case with the Norwood eskers. All three types are found in the same swarm, their axes oriented in the same direction – always pointing towards the super-swarm's divide [2]. More critically, their cores show the same light to heavy, sharp to rounded particle order, moving from bottom to top. And this categorization is not rigid, for all ridge types often share companion features, some types half cemented and some partially covered. Yet, as a species, they are rarely discussed as an ensemble in professional journals, for each ridge type requires a separate and often contradictory explanation. For instance, eskers are generally described as products of intermittent water courses operating either in or on a retreating ice sheet. While drumlins are thought to be moulded into their streamlined shape by forwardly advancing ice sheets which gather up the gravel, sand and soil, organize it into its peculiar inner order and construct its rather delicate outward shape. While this creative activity is taking place, in necessarily opposing ice sheets, moving from non-existing mountain slopes, the same drumlin constructing ice sheet is, according to current texts, carving cemented reproductions out of the rock face.

Illustration 24 *Field of roche moutonnées.*

Compounding all these self-contradictory explanations is the mystery of the source and genesis of the building materials themselves, for this peculiar assemblage of broken and rounded rocky debris does not appear to be the product of glaciers (see PART FOUR of this paper).

Making distinctions between ridge types is necessary for comparing and contrasting the final condition of minor and major ridge systems.

In the case of esker and drumlin formations, the lighter elements (clay, silt and hydrocarbons) located in the leading part of the dropping ribbon are affected by the earth's atmosphere.

In the case of the latter, the load is so great that atmospheric winds will have little or no affect on its passage through the earth's atmosphere. Eskers, on the other hand, have their clay and silt covers torn away by winds and transported elsewhere. On planets without atmosphere, like the moon and Mars, minor ridge systems appear to have all their layers intact.

THE INDIVIDUAL BAND AS RIDGE-MAKER

A critical clue to cometary ridge building is the dynamic character of each particle leaving a comet's nucleus. As each jet ejects a divisible particle, it effectively launches a new comet. This process of continuous sub-division, ejecting from a single jet, creates an individual band within the comet's two-dimensional debris tail.

Each band, as it descends and lands perpendicular to a planet's surface creates a ridge. The effect would be recreated by a truck filled with sand. Sand pouring from an in-line slit in the truck bed would create a continuous ridge; the continuous peak formed by sand exceeding its 'angle of repose' would cause the particles to slide down the sides.

If the earth is moving fast enough, each band will create a separate ridge. If the earth is rotating slower or the band touches down at the geographical polar axis, the bands will overlap creating what geologists call a nappe. These are usually explained by the

dubious theory that mountain ridges are originally folded and sometimes flop over, occasionally covering the foothill of the adjacent ridge.

Spreading And Wheeling

As each band of debris approaches the rotating earth, each following ribbon, originally in line with its neighbour, would not land directly on top of the leading band, but beside it, creating a semi-parallel system.

The separations between ridges would grow wider as the descending ribbons approached the faster moving equatorial region. This radiating pattern can be clearly seen in the Appalachians as the belt approaches the southern states. The earth's progressive acceleration may be observed in the curve of the entire Appalachian formation which wheels around in line towards the west. A more intriguing sinuosity would occur as the descending bands passed over the rotational axis. This would cause a sine curve as the band became influenced by its second approach to the equator, which is now moving opposite sense.

These unusual curving configurations were noted as early as the mid-19th century by Charles Lyell [14].

Ridge Discontinuities

The key to understanding the discontinuities in ridge systems is the following. Each jet represents an individual band of cometary debris. Particulate debris is ejected from jets arrayed on the sunward surface of a comet's nucleus. If there are ten jets operating on the sunward side, there are ten bands in production arrayed along the path of the comet's orbit. As the nucleus rotates to the evening side, the band/jet is cut off, and a new jet/band comes into production on the 'morning' side. This intermittent feature of jetting is responsible for the discontinuous nature of band and, hence ridge production. It is therefore the turning on and off of jets that is responsible for the saddles and gaps between ridges, allowing the migration of settlers and nomads through the forbidding

heights of mountain ranges and providing outlet channels for the meandering rivers on their way down to the sea.

EXPLAINING ESCARPMENTS

More critical to the linkage between tail bands and mountain ridges is the escarpment feature found in all mountain belts. The word escarpment refers to the long, precipitous, cliff like ridge of land or rock, commonly understood to be formed by faulting or fracturing of the earth's crust (illustration 25).

Illustration 25 *Escarpment on the Cumberland Plateau, Tennessee.*

On the opposite side of a mountain ridge's escarpment is what is commonly called a foothill, a slow rise to the edge of the escarpment.

Each mountain belt, whether continental or sub-oceanic, has this asymmetric cross-section, and the escarpments in each mountain belt, always face in the same direction. This feature otherwise inexplicable is determined by the progressive diminution of the

mass of cometary debris as it moves laterally away from the mother jet, i.e. towards the sun. The most massive elements, great boulders or even large splits of the nucleus itself, tend to keep the greatest mass closest to the original nucleus. This is principally due to gravitational constraints. The escape velocity of each particle is determined by its mass, and so the larger elements are necessarily concentrated on the nucleus side of the band. It has also been observed that each particle, escaping from the comet nucleus continues to disintegrate, providing a progressive attenuation of each band.

As the band begins its descent, it will always land the thin edge of the band first and the thick edge last. This orientation delivers the asymmetrical profile of a mountain ridge. As the debris lands in line and the earth passes under the progressively dropping curtain of debris, the foothill begins and elevates towards the escarpment or ridge summit.

Evidence for the heavier side of trailing edge of the band may be seen in the anomalous appearance of great rocks and boulders proximate to great and small ridge systems. They are called erratics and are explained by glacial theory, which believes them to have been conveyed by moving ice sheets. This may explain some erratics but many are arrayed too close to the mountain ridge to be accounted for in this manner.

AN ANCESTRAL MESSAGE

Our ancestors lived and may well have evolved through a tail capture event conventionally dated to approximately 10,000 BC, which involved large scale sudden global changes. This text, taken from the 'Visuddhimagga' Buddhist Text on the World Cycles, may have been derived from the remembered event. It mirrors the projected capture and the sequence of landing debris in uncanny detail:

"When a world's cycle is destroyed by wind … there arises in the beginning a cycle destroying great cloud...there arises a wind to destroy the world cycle and first it raises a fine dust and then coarse dust and then fine sand, and then coarse sand and then grit - stones up to boulders large.... as mighty trees on the hill tops.... The wind turns the ground upside down, large areas crack and is thrown upwards. All the mansions on earth are destroyed in a catastrophe when worlds clash with worlds." [40]

MACROSCOPIC FEATURES OF A COMETARY HYPOTHESIS

In applying a cometary solution to mountain building, further enigmas surrounding mountain building are solved:

Ridge interiors: As the finer materials near the leading edge of each band enter the atmosphere, they are more vulnerable to ambient conditions and, to a degree, scattered by atmospheric winds. It is also likely that hydrocarbons and other gases are concentrated in the same leading area of the band. It is these materials that are mainly captured by earth's floodwaters and the water accompanying the cometary debris. These materials, captured and transported by alluvial processes would account for a significant volume of the sedimentary layers found adjacent to and spreading laterally from the ridge axis. The materials in the following edge, filled with the greatest massive debris, would pile up with little chance for transport. Aside for vegetation and fauna trapped under the swiftly dropping curtain, the rock particles would raise the characteristic asymmetric triangulated profile of the ridge without trapping any life. The resistance to alluvial transport would also account for the unsorted, unstratified condition of the interior of a ridge.

Energy Source: All endogenetic theories of orogeny require an energy source to raise and dispose of mountains. Even the provision of sub-crustal radioactivity has limited the era of mountain building to the lives of radioactive elements. In an exogenetic model, the planet's gravity supplies virtually all the energy needed to create a mountain belt.

Volcanism and Earthquakes: The coincidence of billions of tons of rocks lying on top of a splitting lithosphere is explained by exogeny. In endogeny, the materials must be transported overland keeping the characteristic complex shape of a mountain belt, with its deposits of inter-ridge sediments and accumulations of igneous rock intact.

Igneous to non-igneous rock ratio: The inability of geologists to match igneous rocks to surrounding sediments is a result of the earth-cracking encounter of a great comet's tail with the earth. It also explains the disproportional volume of non-igneous rock.

PART FOUR: SEDIMENT AND EARTH HISTORY – THE DIMENSION OF TIME

We have so far looked mainly at the ridge portion of a mountain belt. We will now take on the question of rocks found adjacent to ridges. It is as important as the other rocks in developing an extraterrestrial model for the earth's mountain belts.

The Britannica states [41] "the proper sequence of the layers exposed in any particular outcrop - be it as extensive as the Grand Canyon or as limited as a small road cut - can be determined.... As the only tangible record of a certain past interval at a certain place, every sedimentary outcrop is essentially the sole source of whatever is to be learned about that interval in that place."

But care must be taken with these records, and The Britannica points out one of their serious deficiencies: "Unfortunately, when the geologist finishes interpreting a single sedimentary outcrop, he has only the story of an unknown time interval from somewhere in the vastness of the past."

The Britannica's cautionary attitude comes from its understanding of the disconnected nature of what is called the geological column. Even the most conservative geologist concedes that, within a particular era, sedimentation proceeded at markedly different rates at different places on the globe.

Nonetheless, these equivocations only mask the fact that most of the earth's history exemplified by complex stratigraphical sequences is entirely missing from substantial expanses of the world's surface.

Compounding this problem are the present gaps in radiometric dating techniques, leaving us without a continuous or precise time record further back than forty thousand years.

Moreover, if an exogenetic theory of crustal formation is right, attempts to objectively date the earth's rocks radiometrically can give us, in most instances, only the age of the cometary debris that comprises over three-quarters of the earth's crust.

THE TIME DIMENSION

There is a clear dichotomy between endogenous and exogenous interpretations of classical sedimentary strata. Geologists see every layer as a particular regime in earth history, the age of which generally reckoned by the time it takes to erode each layer. The cometary hypothesis computes the time required to form a stratum as for a flowing or stagnant body to settle or precipitate its contents.

BEDDING SURFACES

The separations between sedimentary strata are called bedding (planes) surfaces and there are two anomalies associated with them.

The first is the lack of expected erosional activity between each theoretical successive sequence in the geological column. The second anomaly consists of the great time gaps found in every location.

THE GRAND CANYON

Before looking into the make-up and divisions of the geological column, some philosophical reflection on its macroscopic composition is warranted, for the whole idea of stratification seems to present an innate contradiction to the doctrine of uniformitarianism.

When the tourist looks into the abyss of the Grand Canyon, he is asked to believe that the kilometre-deep strata, principally made up of sedimentary rock, are the product of gradual erosion. But the stratification to be observed is far from uniform.

If uniformitarianism implies constancy, what do these substantial and unique layers of metals, limestones, coal beds and multicoloured silicates represent, if not distinct geological regimes?

Science provides sophisticated concepts such as foliation and metamorphosis to explain these purported great expanses of earth history, principally caused by chemical rediffusion, relentless pressure and infinite time. The problems with these theories, which we will deal with later, are that they do not get around a basic contradiction. The existence of distinctive strata, some of which are thousands of metres thick, each member supposed to represent some unique set of unreplicable events, directly contradicts the doctrine of uniformitarianism.

THE UNIFORMITARIAN WORLD

In the uniformitarian world of geology, the processes we are instructed to observe in the interpretation of the formation of strata are of a seasonal nature. These yearly sedimentary depositions are recorded in the settling clay and silt of rivers and other catch basins, as is the yearly snowfall that accumulates and compresses into measurable layers of ice in the alpine and arctic regions. These relatively thin pages of the geological record, however, are not the stuff of the Grand Canyon, with their hundred metre deposits of cemented silica and carbonate debris. The uniformitarianist time unit is ideally an eternal cycle of the unchanging seasons, and if we accept this premise we should be gazing into a canyon consisting of a monochromatic wall of millions of thin, uniform, annual layers. Obviously other processes are at work here, for what we see is a bewildering array of multicoloured monolithic layers of varying thicknesses.

The author of a standard petrology text had the following to say of these sharp boundaries separating sedimentary strata:

"Bedding surfaces commonly are generated by contrasting textures... for example, the contrast between the very coarse texture of the conglomerate and the finer texture of overlying sandstone. What mechanism produced the boundary between the coarser- and finer-grained layers? Was it a rapid decrease in stream current velocity; or a lateral shift in channel position; or the transgression of an offshore marine sand bar over a gravel beach? The causes of bedding surfaces (planes) are many, and often they are not

understood. Their existence, however, means that something must have changed during the interval of time represented by the infinitely thin surface; perhaps a change in water chemistry caused incipient cementation of the earlier sediment; or perhaps there was a change in water temperature resulting from a change in solar radiation; or perhaps a change in stream current velocity occurred as a result of a spring flood on April 7th of the early Middle Devonian. It is worth remembering that most of the time since the earth was formed is represented in the geologic record by bedding surfaces, not by rocks. Hence, the bedding surfaces we see in outcrops deserve careful examination. Their commonness should not make them less noteworthy." [42]

But it is not just these invisible divisions that are anomalous, it is the strata on each side of this divide. They are radically dissimilar in texture, thickness and chemical makeup. In the carboniferous, for instance, a thin layer of fossil-filled clay may be easily removed from the fossil-free coal seam, which in turn, may be easily broken away from the upper shale stratum. These repetitions, called cyclothems or rythmites, repeat themselves as much as 100 times, each stratum separated by a mysterious bedding plane.

George McCready Price spoke colourfully of the lack of erosional activity between sedimentary layers: "Nature must have served an injunction on the action of the elements and they had to continue in the neither status quo for millions of years, the neither water wearing away nor building up over any part of this taboo ground during all this time." [43]

Price was particularly referring to the boundaries between great gaps in earth history.

UNCONFORMITIES - MISSING EARTH HISTORY

The sequence of rocks in the Grand Canyon's walls suffers from the same anomaly as the rest of the geological column, in that most of it is missing.

The tourist passing by an outcrop in the canyon wall is advised by a brass plaque that the Ordovician and Silurian periods of the Palaeozoic era are missing from the Grand Canyon sequence, a lacuna, by accepted chronology, of 100 million years.

These gaps are called unconformities, and are so common in the geological column that they are regarded as stratigraphical signposts rather than geological anomalies.

Both Lyell and Darwin were quite aware of these great gaps in the geological record. Darwin was quite vivid on the subject in 'The Origin of Species':

"But we know, for instance, from Sir R. Murchison's great work in Russia, what wide gaps in that country between the superimposed formations; so it is in North America and in many other parts of the world. The most skilful geologist, if his attention had been exclusively confined to these large territories would never have suspected that during the periods which were blank and barren in his own country, great piles of sediment, charged with new and peculiar forms of life, have elsewhere been accumulated." [44]

What Darwin failed to point out is that these great piles of sediment are usually organized into confined orderly layers, and there appears, typically, to be no sign of erosional activity separating them.

Explaining Unconformities and Bedding Surfaces

A common solution to unconformities – the apparent great gaps in the geological column, and bedding surfaces - erosion-free surfaces between sedimentary strata - is that no appreciable time passed in the deposition of these strata.

Early Ideas on Erosion

The issue of the creation and disposal of sediment was still an important component of geological enterprise in the late nineteenth century.

Not only were the earth's sediments assumed to have been eroded from its mountain belts, some geologists claimed erosion as the tool for sculpting these prominences as well.

Before plate-tectonics became the instrument of choice for pushing and pulling sediments into mountain belts, late nineteenth century geologists contested over whether rushing water or great splits in the earth's crust were responsible for these mighty ridge systems.

Some geologists believed that great floods carved out mountain belts. Skinner reports that "Buch ... declined to accept erosion as a major factor in creating relief - for Buch, everything was a consequence of plutonic upheaval in some form. An inheritance of this conviction was the theory, still defended in the 1870s, that the deep Alpine valleys were fissures in the crust and certainly not the product of the puny streams barely visible from the peaks they had supposedly created." [19]

Whatever the source of mountain belts, however, no one doubted the requirement of sediment disposal.

Sediment Disposal – Too Much or Too Little?

Both endogenous and cometary models pose contrasting problems. The current model appears to generate too much sediment, and the cometary model, too little.

Not only do today's great rivers disgorge unexpectedly large amounts of sediment, the total sedimentary burden, monumental when computed at uniform rates, cannot be found at continental margins.

Computing Sedimentary Output

What Lyell and his contemporaries brought to ancient observations of the sedimentary output of great rivers was the discipline of computation. When measurements were made, the numbers were truly impressive.

THE RATE OF DENUDATION

Even now in regions where the uplifting and relief-creating mechanisms have been inoperative for several hundreds of millions of years, the lands have been reduced by denudation to low and often nearly featureless plains. Yet, it is clear that any modern theory of landform evolution must take into account the possibility of a periodic regeneration of continental elevations, particularly of large-scale relief features. For without such regeneration, there would be no continents or mountains even today, given their present rates of erosional destruction.

As early as 1830, Lyell reported an attempt to measure the annual rate of sedimentary deposition in the Ganges delta. In his last edition of 'Students Elements of Geology' [14], he made the following report on the Mississippi River:

"That river drains a country equal to more than half the continent of Europe, extends through twenty degrees of latitude, and therefore through regions enjoying a great variety of climate, and some of its tributaries descend from mountains of great height.

The Mississippi is also more likely to afford us a fair test of ordinary denudation, because, unlike the St. Lawrence and its tributaries, there are no great lakes in which the fluviatile sediment is thrown down and arrested in its way to the sea. In striking a general average we have to remember that there are large deserts in which there is scarcely any rainfall, and tracts, which are as rainless as parts of Peru, and these must not be neglected as counterbalancing others, in the Tropics, where the quantity of rain is in excess. If then, argues Mr. Geikie, we assume that the Mississippi is lowering the surface of the great basin which it drains at the rate of one foot in 6000 years, 10 feet in 60,000 years, 100 feet in 600,000 years, and 1000 feet in 6,000,000 years, it would not require more than about 4,500,000 years to wear away the whole of the North American Continent if its mean height is correctly estimated by Humboldt at 748 feet. And if the mean height of all the land now above the sea throughout the globe is 1000 feet, as some geographers believe, it would only require six million years to subject a mass of rock equal in volume to the whole of the land to the action of sub aerial denudation. It may be objected that the annual waste is partial, and not equally derived from the general surface of the country, inasmuch as plains, watersheds, and level

ground at all heights remain comparatively unaltered; but this, as Mr. Geikie has well pointed out, does not affect our estimate of the sum total of denudation. The amount remains the same, and if we allow too little for the loss from the surface of table-lands we only increase the proportion of the loss sustained by the sides and bottoms of the valleys, and vice versa."

Sourcing Sediment

Lyell's computations conjure up a vertiginous sedimentary edifice. Assuming approximately 450 million years for the estimated duration of all fossil-bearing sediments, a pile of rock approximately one hundred times the average height of the North American continent [70,000 feet] would be the grist required for steadily feeding Lyell's imagined sedimentary mill.

It is understandable that early geologists assumed that the Appalachians were only the latest of a series of mountains that had arisen and eroded away to feed the Mississippi.

Lyell's Rationale for Sedimentary Production

With this enormous rate of denudation, the superabundance of sediments flowing into the earth's deltas did not appear to faze Lyell. He had assumed that 90% of the earth's sediments, essentially the missing portions in the geological column, were represented in the debris floating down the Mississippi and other great rivers. Moreover the deep strata found in inter-mountain basins such as the Appalachian coal fields were, to him, examples of vertically reciprocating terrains, which replicated in the ghostly past, the necessary source of the superabundant sediments.

A scenario, which imposed regimes of repeating alternations of land and sea, removed the spectre of a primal gigantic highland dozens of times higher than present mountain ranges.

THE PRISTINE APPALACHIANS

Both Darwin and Lyell assumed that these "great piles of sediment" were the meagre remains of sediments, which had once filled the great gaps in the geological column.

Unfortunately there seems to be little evidence that the Appalachians, like most mountain belts, have been eroded to any extent. The peaks of the ridges are sharp and the carboniferous sediments contained by the ridges are, by current calculations, over 200 million years old at their surface.

It is inconceivable, however, that on Lyell's restless earth, on which continents casually change places with oceans, areas such as the earth's coalfields had remained inviolate for over 200 million years. This problem continues to be unexplained no matter what model, past or present is applied.

WHERE DID ALL THE REGOLITH GO?

Even if we can accept the idea of 200 million year old formations uniformly resisting the ravages of erosion, there is yet another problem clinging to a theory of steady state erosion. We cannot find any traces of sediment at continental margins, or further offshore, consistent with either Lyell's or any other estimates. Where did all the sediments go?

THE GLOMAR CHALLENGER

In the 1960's, the scientific voyage of the Glomar Challenger (illustration 26), having made an extensive investigation of the continental shelves, found only a fraction of the expected sediments.

Illustration 26 *The Glomar Challenger.*

In evaluating the expedition's results, Skinner stated the problem. "Geologists are able to make very good estimates of deposition of erosional sediments into the world's oceans. The rate is such that the basins would be filled in tens of millions of years. Even allowing for adjustments of isostacy.... this was far shy of the number of the several billion years generally accepted as the age of the earth." [19]

This "gross inconsistency" lasted for many years until plate tectonics came to the rescue, by reintroducing John Herschel's nineteenth century theory of sediment-driven isostacy with one substitution. Instead of the pressure of sediment melting and driving magma beneath the continents, providing elevation for the rock cycle, Plate motion would also act as a global broom, sweeping the surplus sediment under the continental carpet. Skinner reports the insight.

"... The accumulation of sediments near the continents no longer presents a problem. The sediments are continually scraped from the plate as it takes its downward plunge at the continental margin. The accumulation is presumably impacted into the continent and rebuilds and maintains it in some crude isostatic equilibrium."

A Solution to the Sediment Paradox

A solution to the paradox of too much or too little sediment may be solved if we turn away from a partly endogenous uniformitarian model. Let us consider the sediments now filling our estuaries as the remains of a series of cometary encounters that ceased as recently as 2600 years ago. We are, from this perspective, looking at the sedimentary deposition from a recent cometary encounter, rather than the persistent denudation of cycling continents.

Mountain Belts: A Concrete Solution

The main reason that highlands seem impervious to erosion is that much of it consists of sedimentary rock, and this type of rock is concrete. It takes a great deal of cement to create enough concrete to cover the earth with mountain belts. Where did it come from?

The 'True Rocks'

Much of the fragile rock structures, their shales [mudrock], clay, and layers of sand, gravel and silt, are vulnerable to erosion. The layers of sandstone, aragonite, and limestone cover and support the more fragile strata. The ridges of great mountain belts contain masses of conglomerate rock, which help retain its impressive structure.

What makes these rocks resistant to the erosive effect of flowing water is their well-known structure – the 'true rocks' are essentially concrete. This is the same material that the Romans used to build their coliseum and famous baths, and the material preferred today for skyscrapers, stadiums and swimming pools.

Sedimentary rock and concrete are both composed of two main ingredients – a matrix or filler, usually gravel and sand, and cement. The cement is the glue that holds the matrix together.

The information found in most high school textbooks stating that the earth's rocks require heat and pressure to form, is, ironically quite the contrary. Once water is poured into container of sand, gravel and cement, the reaction produces heat and within hours, the slurry hardens into the same material holding mountain belts together.

The existence of ready-made rock therefore dampens the requirement of time, for the immediate formation and subsequent slow breakdown of mountain belts. The remaining problem of recent overproduction of continental sediments still must be explained, but first, a note on the source of cements.

The Properties of Cement

The critical ingredient in concrete is calcium carbonate; the glue that holds all true rocks together.

The chief ingredient of cement is Lime, also called burnt lime, calcium oxide, caustic lime, calx, and quicklime. It is a white or grayish-white, odorless, lumpy, very slightly water-soluble solid, CaO, that when combined with water forms calcium hydroxide (slaked lime). Once set, this material can bind almost any dry debris into a versatile conglomerate.

Industrial cement is manufactured by heating calcium carbonate, limestone, or oyster shells, in an oxygen free environment. It does not appear naturally anywhere on earth. Occasionally weak acids [carbonic] will produce calcium carbonate in solution. This is the source of stalagmites and stalactites in caves. But this process cannot account for the cements found in the earth's great rock systems, some of which are almost pure calcium carbonate.

Recent Cementing Operations

A relatively straightforward approach to dealing with the overabundance of sediments in the current geological period is to, once again, tamper with our established dogma of bottomless uniform geological time.

The most recent slice of the geological column is called the Holocene. In the human time dimension, it is the period when the ice sheets covering North America and Eurasia pulled back to reveal a new landscape, rich in agricultural soils. The material most associated with this advance to civilization is called loess.

Loess

Most of the great river valleys of Europe and North America are covered with a loam-like material called loess. Multi-layered and fossil-free, it has been identified as the outwash of the great ice sheets of the last ten to fifteen thousand years. The loess, we are told, was supplied by great winds of this era, which deposited thousands of cubic kilometres of the silt-like materials on the retreating ice. These winds are conceded to have a speed and direction that has no relationship to present day weather patterns.

Chemistry

Microscopically, loess, when not worn by alluvial processes, has an angular sharp-edged shape, which makes its unstratified deposits quite porous, in most cases at least 50% air. Chemically, it is complex and heterogeneous, made up mainly of quartz and with some clay minerals, micas, hornblende, and pyroxene added into the mix. By weight, up to 40% of the sediment may be carbonates. The composition of loess "is so elastic that it tells us little about the rocks in which the minerals originated." [45]

DOMAIN

Loess underlies an enormous aggregate area of at least 10 million square kilometres in North America and more than 1.8 million square kilometres in Europe. So vast are the deposits, that Flint states that a large proportion of the buried Quaternary soils now known, are developed in loess. [45]

LOESS'S PROVENANCE

In researching the source of these materials, geologists are generally content to indicate the geographical sources of the wind-borne particles and not the actual method of their production. Flint cites deserts, outwash and recently exposed till, adding some perplexity to the problem by admitting that once covered, the loess deposits are not easily airborne.

Some effort is expended in developing a method for these particles to lift off the ground, and we are led to believe that sand particles help the take-off by kicking the lazy silt into the air. [45]

These hypotheses only obscure the fact that outwash, deserts and till deposits are only secondary sources of loess and, even if perfectly able to rise freely and circulate to northern latitudes, could not account for the thousands of cubic kilometres that are found in some North American deposits.

The current attitude towards the source of loess deposits is to point to the inferred origin of the prevailing winds. Unfortunately, this sometimes suffers from a nationalistic bias.

Geologists never seem to own up to a local source for loess. Each nation disclaims the intrusion, as if the loess were some old version of acid rain. Since much of the Pleistocene loess shows a westerly directionality, we have the geologists, from a bird's eye view, pointing perpetually eastward, quite naturally outside of their own territories.

Another difficulty in explaining the origin of loess is that a good part of the loess found on the earth's surface does not seem to be the product of alluvial processes, a primary condition of their eventual transport and deposition by air.

NORTHERN CHINA

The greatest deposits of loess not located adjacent to Holocene glaciations occur in Manchuria, where they are found in unstratified conglomerations as deep as one hundred metres (illustration 27). They were first described in the late nineteenth century.

Illustration 27 *Central Chinese loess plateau, near Jingchuan, Gansu, China.*

The writer of the Chinese report registered his frank disbelief that these deposits could have been alluvial in origin. He noted that loess was found in formations as high as seven thousand five hundred feet and "the uniform composition of this material over

extended areas, coupled with the absence of stratification and of marine or fresh water organic remains, renders impossible the hypothesis that it is a water deposit." [46]

The writer especially noted the use the Chinese peasants made of the loess, for the soil yielded up to three crops per year and required no manuring. "Wherever this deposit extends, there the husbandman has an assured harvest, two or even three times a year. It is easily worked, exceedingly fertile, and submits to constant tillage, with no other manure than a sprinkling of its own loam dug from the nearest bank." [46]

The material not only provided homes which were dug out of the side of its cliffs, but also partition walls and furniture were made of this remarkable material. "Whole villages cluster together in a series of adjoining or superimposed chambers, some of which pierce the soil to a depth of more than 200 feet." [46]

The reason for the extraordinary qualities of this material is that it is 'nailed' together by tiny limestone capillaries, creating a lightweight masonry composite. These peculiar tubules provide the capillary action that draws the moisture up from the bedrock. This peculiar vertically oriented structure led geologists to state that this formation was vertically stratified, probably giving the reader the mistaken belief that the materials were conventionally stratified into some sort of bizarre vertically oriented structure.

THE COMETARY ORIGIN OF LOESS

The process by which loess is cemented together is not well understood, but it is obviously some alluvial or draining process.

In 1931 J.B.Penniston, writing in *Popular Astronomy*, suggested that loess was meteoric in origin. He also offered an explanation for the formation's vertical stratification and noted the unlikelihood that the sharp-edged grit could have been worn down by water. After noting the similarity loess shared with meteoric and volcanic particles, and its dissimilarity to "rock flour," the product of glacial grinding, he turned to the peculiar calcareous tubules, suggesting that "water, as from a fine drizzle of rain, would descend unevenly, and coming in contact with newly fallen meteoric matter, the finest material would be segregated along these lines of flow, ultimately becoming crystallized as is found in the hollowed tubes in the loess." [47]

The most interesting element of his hypothesis was his choice for the mineral source of the calcareous tubules. The loess deposit itself, devoid as it was of fossils, made a poor source of calcium. The hard shells of some marine organisms, even if they contributed to the materials, would have had to undergo bathing in carbonic acid or other organic acid baths in order to dissolve. Ordinary rainwater would not do the job. The astronomer indicated that calcium oxide (lime) mixed with rainwater would create these tubules. Calcium oxide, however, was not normally found in earth minerals. Penniston then pointed out that meteorites did contain calcium oxide in appreciable amounts. If this powder were distributed within the loess deposits, it would account for the phenomenon.

Other Cemented Landscapes

The fingerprint of exogenous calcium oxide may be found in other recent geological features.

Deserts and semi-arid landscapes are covered by a tough concrete composite called hardpan. Hardpan usually is found less than a metre beneath of weathered soils and is so tough that dynamite or heavy road building equipment is necessary to tear it up to prepare the land for agricultural purposes. So recent is this formation, in geological terms, that hardpan is found covering human habitations. C14 analysis has found it to form as early as 2400 years ago.

PART 5: LOOKING UNDER

In the conclusion of this section, the mountain belt will be followed as it dips below the continents. The oceans will be removed to reveal a global lithosphere covered by mountain belts.

The cometary hypothesis assumes that a captured great comet's tail capable of wrapping its rocky belt around the earth would not discriminate between land and sea.

Geologist and geographers, still wedded to older traditions distinguishing between the domains of land and sea, tend to give different names to these mountain belts depending on their travels above and below sea level. On the Continents, Mountain belts are called chains and ranges, but when they enter the sea they become seamounts and abyssal hills.

It will be argued that great continental mountain belts, when they enter the ocean depths, show only those changes to be expected from dropping through an atmospheric medium and then sinking into a watery environment.

SEAFLOOR EXPLORATION

The difficulty of topographically linking the domains of land and sea is understandable from a historical point of view. The ocean depths for millennia were known only to the unfortunate mariners who drowned in their efforts to conquer its immensities. The ocean bottom remained terra incognita until late in the 20th century.

To quote a recent critique of plate-tectonics, "When plate tectonics was first elaborated in the 1960s, less than 0.0001% of the deep ocean had been explored and less than 20%

of the land area had been mapped in meaningful detail. Even by the mid-1990s, only about 3 to 5% of the deep ocean basins had been explored in any kind of detail …" [48]

THE EARTH'S GREATEST MOUNTAIN BELT

By far, the greatest of the sub-oceanic mountain belts is now called the Mid-Oceanic Ridge. The United States Geological Survey reports:

"In the 1950s, oceanic exploration greatly expanded. Data gathered by oceanographic surveys conducted by many nations led to the discovery that a great mountain range on the ocean floor virtually encircled the Earth. Called the global mid-ocean ridge, this immense submarine mountain chain -- more than 50,000 kilometres (Km) long and, in places, more than 800 km across -- zigzags between the continents, winding its way around the globe like the seam on a baseball. Rising an average of about 4,500 meters (m) above the sea floor, the mid-ocean ridge overshadows all the mountains in the United States except for Mount McKinley … in Alaska (6,194 m). Though hidden beneath the ocean surface, the global mid-ocean ridge system is the most prominent topographic feature on the Surface of our planet."

PLATE-TECTONICS AND THE MID-OCEANIC RIDGE

The idea of splitting continents was originally stimulated by the nesting quality of South America's and Africa's opposing shorelines. The eventual triumph of this idea is credited to the persistence of a German meteorologist named Alfred Wegener. Although Wegener provided the catalyst and framework for plate-tectonics, there was a critical piece missing.

What was the nature of the platform upon which the splitting took place? Did the earth's surface simply stretch as the continents parted? Geologists, contemplating an inflating global sphere, without any easily understood mechanism, were quite sceptical of the entire theory. An alternative, however, arose with the discovery of a large ridge system dividing the Atlantic Ocean. This knowledge had been around for some time, acquired by weighted lines. The structure, however, was quite sketchy. The data

acquired by the German research vessel 'Meteor' in the late 1920s elaborated the system. These data showed the existence of a central valley along much of the crest of the Mid-Atlantic Ridge.

In searching for a mechanism for continental drift and its corollary, sea floor spreading, the Mid-Oceanic Ridge soon became the necessary part of the theory.

Positioned, as it was, mid-way between Europe and North America, the temptation was great for designating these breaks in the ocean floor as a major parting line for a super continent. In the early sixties, a series of quasi-parallel geo-magnetic strips appearing to spread from both sides of the system displayed signs of alternating reversed polarities. This convinced most geologists that the creeping sea floor, while still hot, picked up the prevailing geo-magnetic field's direction. Theorists concluded that the Mid-Atlantic Ridge was the parting line for two great moving rigid plates slowly pushing Europe and North America apart. They believed that the moving oceanic plates, when meeting continental margins, were subducted into the earth's molten interior. The golden principle of balance and uniform rate was met, and the theory gained favour.

Today The Britannica proclaims: "Plate tectonics has revolutionized virtually every discipline of the Earth sciences since the late 1960s and early 1970s. It has served as a unifying model or paradigm for explaining geologic phenomena that were formerly considered in unrelated fashion. Plate tectonics describes seismic activity, volcanism, mountain building, and various other Earth processes in terms of the structure and mechanical behaviour of a small number of enormous rigid plates thought to constitute the outer part of the planet (i.e., the lithosphere)." [49]

Exploration of the Mid-Atlantic portion of the Mid-Oceanic Ridge, has been, in recent years, examined more intensively through a number of ambitious deep sea drilling expeditions.

These recent data should help determine whether the 50,000-kilometre "mountain chain" marks the zone from which plates have been separating for 200 million years or, in the alternative, it is the earth's longest captured tail segment.

Do Mountains Move Apart?

Some of the assumptions underpinning plate-tectonics will be challenged below. These arguments are not intended as a general critique of the theory. It is only where plate-tectonics claims to account for the creation of mountain belts that swords must be crossed.

Those searching for more exposition and criticism of plate-tectonics are referred to [48].

Once a Mountain Belt, Always a Mountain Belt

The casual mention of the Mid-Oceanic Ridge as the earth's largest mountain range in geological publications must not be taken lightly, for much of the cometary hypothesis is based on this assumption. There is a strange dichotomy in the nomenclature, however, beginning with the more familiar description of the structure as a ridge.

When is a Ridge a Mountain?

Present geological nomenclature is clear; a ridge is only one element of a mountain belt, also called a mountain system or chain, which represents a series of interconnected or geologically related mountain ranges.

The Mid-Atlantic 'ridge' is at times over 700 kilometres wide and is made up of dozens of ridges. The misnomer, which implies a singular geological feature probably, arises from the original notion that mountains originated from a 'bulge' created by sub-lithospheric upwardly welling magma. The magma broke through the lithosphere, presumably created the 'ridge' as it broke through the surface rock and divided into two diverging plates.

A more recent interpretation sees the lithosphere stretching to the breaking point, allowing the upwelling magma to then part and spread. This notion, thanks to plate-tectonics is still with us, since the theory requires a clear and seamless connection between a rising plume of magma and the growing sea floor. This requirement for diverging plates puts undersea mountain building into a theoretical straightjacket. The plate-tectonic image seems to have nothing to do with the picture we have of continental mountain belts which are believed to be the product of sediments which, in some manner, are turned into mountains through convergent forces. How divergent plates find sediment in the first place and then form these sediments into parallel ridge systems while steadily moving apart has not, to my knowledge been explained. Even more troubling is how continental mountain belts which are considered principally sedimentary structures, mutate into an igneous species as they drop beneath the oceans.

Does the Mid-Oceanic Ridge Meet Cometary Criteria?

If the Mid-Oceanic Ridge, like all other mountain belts, both continental and sub-oceanic, is the product of a comet's tail, they should share the following characteristics: The ridge and stratified elements of a mountain belt should represent a uniform non-igneous structure lying upon the lithosphere.

The volcanic and earthquake regime - the product of local shearing pressures- should be confined to the mountain belt. Moreover, the magma extruding from the shearing zone should be discontinuous and confined, as well, to the ridge zone.

The Continuity of Mountain Belts

In Lyell's time the question of the nature of mountain ridges was controversial with his explanation favouring a subterranean magmatic source [14]. Toward the end of the 19th century, geologists maintained that the ridge structure still was sedimentary in

nature, and this finding, in regard to continental mountain ridges, is the present conventional interpretation. Applying this finding to the Mid-Oceanic Ridge, however, represents a calamity to Plate-tectonics. It is difficult enough to explain how sediments erode under water; it is even more difficult to account for such large accumulations located at the leading edge of the diverging plates.

What advocates of plate-tectonics seem to be claiming is that the great sub-oceanic ridge systems are a single longitudinal bulge in the lithosphere caused by upwelling magma. This theory is contradicted by recent seismic profiling that indicates that the ocean floor cuts across the Mid-Oceanic Ridge system. This is also consistent with the revolutionary findings that the Appalachians were not rooted in North America's bedrock.

On a purely rational basis, developing a 19th century explanation for mountain ridge formation leads to an unfortunate dichotomy. It implies that the Mid-Atlantic-Ridge requires one type of genesis underwater and another when it emerges to form the island of Iceland. The same absurdity would apply to Japan, the West Indies and other emerging mountain belts.

Ridges, Sea Mounts and Abyssal Hills

Another difficulty concerning the double ridge concept is the discovery that over thirty per cent of the ocean floor is covered with ridge systems, many of which have volcanic and earthquake zones associated with them.

Abyssal hills are the most widespread geological feature on the earth. Like their continental cousins, abyssal hills and sea mounts run parallel to each other and this includes the Mid-Oceanic Ridge system. Moreover abyssal hills and mountain belts show the same peculiarity of an assymetrical ridge profile.

Abyssal hills and sea mounts are considered, like the Mid-Oceanic Ridge, to be volcanic in origin. These discoveries have forced geologists to consider the magma extruding structures to be new parting lines in the plate system. These inconsistencies, and others, have increased the original number of plates from ten to over one hundred and growing

Do Plates Move Apart?

Mountain belts, if cometary in origin once lay down, would have little lateral movement. Their great mass could shift downward, to accommodate vertical compressive forces. The magma-disgorging cracks in the lithosphere are, therefore, in the cometary hypothesis, the result of crustal shearing. But this shearing activity would be a local event, extending little further than the mountain belt itself.

Gaps in the Mid-Oceanic Ridge

There are large sections of the Mid-Atlantic Ridge that are missing. David Pratt reports: "Several parts of the ridge have no important fracture zones or even traces of them. For instance, they are absent from a 700-km-long portion of the Mid-Atlantic Ridge between the Atlantis and Kane fracture zones. There is a growing recognition that the fracture patterns in the Atlantic 'show anomalies that are neither predicted by nor ... yet built into plate tectonic understanding" (Shirley, 1998a, b).'" [48]

This anomaly has led to the admission that plate motion is episodic. Even if we could accept this ad hoc explanation, the substantial gap indicates that no spreading activity had been going on in this area for over 200 million years. How hundreds of kilometres of plates could advance while adjacent crust remained immobile is not easily explained.

These discontinuities, however, are typical; in both continental and sub-oceanic mountain belts reinforcing the hypothesis that the great mass of rocky debris concentrated in mountain belts are the source rather than the product of volcanism.

Is There any Evidence That the Mid-Atlantic Ridge Moves Apart?

A cometary mountain belt is essentially a static body, its motions, if any, would be vertical, creating earthquakes and volcanic activity in its settling.

Evidence of horizontal movement at the Mid-Oceanic Ridge, on the other hand is tenuous at best. Drilling programs in the two decades have found contradictory physical motions and radiometric dating, and report that forces expected to be found at parting crust are missing. Such forces as can be measured are not extensional but compressive.

"In Iceland, the largest landmass astride the Mid-Atlantic Ridge, the predominant stresses in the axial zone are compressive rather than extensional. Furthermore, the rift valley floor in Iceland is sinking and the bordering plateau is also sinking, at rates that increase toward the axis, and this is difficult to reconcile with the PT [plate-tectonic] hypothesis of axial upwelling, single-stage accretion, and spreading (Keith, 1993)." [48]

These data, however, are consistent with the exogenetic hypothesis, which holds that cometary debris of sufficient mass will sink, compressing the bedrock sufficiently to cause local shearing and subsequent volcanic activity.

Compounding the problem is the measurement made at Iceland and other locations suggesting that there is little consistent spreading at the Mid-Oceanic Ridge: "Geodetic surveys across "rift" zones in Iceland and East Africa have failed to detect any consistent and systematic widening as postulated by plate tectonics. After finding no tensile motions associated with the East African rift, the investigators felt forced to postulate that plate motions there must be episodic (Asia et al., 1992)." [48]

Escaping Magma

The plate-tectonic paradigm suggests wide plumes of magma, parting from a dome of hardening rock into two even plates. In a cometary mountain belt, on the other hand, escaping magma would not extrude evenly but escape from local shearing zones

spasmodically, and flow along the channels created by the recently formed ridge systems. They would continue the parallel motion until a gap in the ridge system would provide an outlet, allowing the magma to flow outward from the ridge axis. The following report from a recent oceanographic expedition confirms this postulate:

"Side-scanning radar images show that the mid-ocean ridges are cut by thousands of long, linear, ridge-parallel fissures, fractures, and faults. This strongly suggests that the ridges are underlain at shallow depth by interconnected magma channels, in which semi-fluid lava moves horizontally and parallel with the ridges rather than at right angles to them. The fault pattern observed is therefore totally different from that predicted by plate tectonics, and it cannot be explained by upwelling mantle diapirs as some plate tectonicists have proposed (Meyerhoff et al., 1992a)." [48]

Zones of Reversed Polarity

The phenomenon that helped convince geologists initially sceptical of Plate-tectonics were zones of reversed polarity concentrated along the axis of the Mid-Atlantic Ridge. A United States Government periodical states the case:

"As more and more of the seafloor was mapped during the 1950s, the magnetic variations turned out not to be random or isolated occurrences, but instead revealed recognizable patterns. When these magnetic patterns were mapped over a wide region, the ocean floor showed a zebra-like pattern. Alternating stripes of magnetically different rock were laid out in rows on either side of the mid-ocean ridge: one stripe with normal polarity and the adjoining stripe with reversed polarity. The overall pattern, defined by these alternating bands of normally polarized rock became known as magnetic striping.

The discovery of magnetic striping naturally prompted more questions: How does the magnetic striping pattern form? And why are the stripes symmetrical around the crests of the Mid-ocean ridges? These questions could not be answered without also knowing the significance of these ridges. In 1961, scientists began to theorize that mid-ocean ridges mark structurally weak zones where the ocean floor was being ripped in two lengthwise along the ridge crest. New magma from deep within the Earth rises easily through these weak zones and eventually erupts along the crest of the ridges to create

new oceanic crust. This process, later called seafloor spreading, operating over many millions of years has built the 50,000 Km-long system of mid-ocean ridges. This hypothesis was supported by several lines of evidence: (1) at or near the crest of the ridge, the rocks are very young, and they become progressively older away from the ridge crest; (2) the youngest rocks at the ridge crest always have present-day (normal) polarity; and (3) stripes of rock parallel to the ridge crest alternated in magnetic polarity (normal-reversed-normal, etc.), suggesting that the Earth's magnetic field has flip-flopped many times. By explaining both the zebralike magnetic striping and the construction of the mid-ocean ridge system, the seafloor spreading hypothesis quickly gained converts and represented another major advance in the development of the plate-tectonics theory. Furthermore, the oceanic crust now came to be appreciated as a natural "tape recording" of the history of the reversals in the Earth's magnetic field." [50]

This writer, like many other geologists, believes the Mid-Ocean Ridge to be one continuous, minutely moving entity, "torn apart" along its entire length. The problems associated with this image have already been addressed, except for the matter of the famous parallel bands of reversed magnetism.

Moreover the "zebra patterns" referred to by the writer relates to the illustrations shown in many textbooks. These drawings have been challenged as being no more than hopeful schematics.

Acquiring Reversed Polarity

There are a number of methods for inducing a magnetic field in ferrous materials, but the most common industrial technique is the method of manufacturing permanent magnets.

This is achieved by heating and then cooling the material whilst in a steady magnetic field. Here the thermal energy agitates the grains and domains so that they can be easily rotated by even a modest magnetic field; when the temperature is reduced, the magnetic domains remain "frozen" in their new positions.

If the extrusion of magma from lithospheric shearing is a local event, its final pooling dependent on the structure of the confining ridge structure, and the freezing dependant on local passage of the cooling magma, then a the less uniform pattern of reversed magnetism is more coherent. This pattern is also consistent with a single spasmodic event, rather than the imperceptible even spreading of the ocean floor projected by plate-tectonic theory.

As for the repetition of alternating bands of reversed polarity as they spread from the ridge axis, they are possibly a reflection of a number of discrete cometary encounters. In the first, which presumably was the most traumatic, the lavas spread furthest. The subsequent lesser events, each with its own new electromagnetic environment, created zones of discrete reversed polarity.

The Mountain Belt: Its Source, Structure and Centrality to Exogeny

Since mountain belts contain virtually all the earth's topography, it follows that orogeny, or mountain building is determined by the source and structure of mountain belts.

Endogenists believe mountain belts to be a stage of the 'Rock Cycle', derived from rising molten rock, formed and elevated by energies deep within the earth and fated, in the progress of deep time, to be eroded and recycled.

The exogenist model, on the other hand, sees the mountain belt as a permanent, independent feature of the earth's crust. This accretionary phenomenon ignores the distinctions of land and sea, spreading its unique features in earth-circling belts. Moreover, mountain belts are a permanent crustal feature. Aside from the eroded materials mainly found in the earth's estuaries, mountain belts have suffered little from denudation, showing no evidence of cycling back into the earth's interior.

Most importantly, the cometary hypothesis presents a single uniform model for mountain building, whether continental or beneath the sea. Because plate-tectonics began as a method of understanding the origin of continents, mountain building tends

to be a by-product of the art, one that admittedly finds the process somewhat obscure. As a result of this uncertainty, orogeny still holds on to a variety of 19th century ideas.

For example geologists still refer to the Rockies of the United States west coast as a "folded" feature, while the Appalachians are no longer so. Investigation having shown them to be a superficial formation, they are now believed, by necessity, to have been transported from other locations.

When mountain belts descend into the ocean depths, their origins, in conventional terms, become even more obscure. Earth's greatest mountain belt, according to plate-tectonics, sits upon a slowly dividing plume of magma. A mountain belt requires elevation, and so we are, perforce, transported back in time to Lyell, who believed that mountains were created by raising magma. [14]

How mountain belts, which primarily consist of an enormous accumulation of non-igneous matter, could be sitting on a slowly parting "tear" in earth's crust, seems to be opposed to both logic and evidence. If the materials closest to the diverging plates are supposedly the youngest, what is a great mountain belt, made up primarily of non-igneous and layered sedimentary rock, sitting upon a diverging set of plates?

The lack of a coherent theory of orogeny leads to a haphazard approach to explication. Continental mountain belts are the product of compressive forces on one coast, and complex gravitational forces conveying ready-made mountain ranges, on the other. At Mid-Ocean, mountain belts are considered the product of diverging plates.

Energy Requirements

The cometary hypothesis is particularly useful when it comes to the prickly question of energy requirements. For centuries geologists have struggled to conjure with the question of the enormous energy necessary to elevate mountain belts.

Early natural philosophers resorted to great underground burning caverns. Post-renaissance thinkers assumed the earth's original molten condition would suffice. This logical hypothesis faltered, however, when the cooling appeared too rapid to match the much slower rate of topographical growth demanded by Uniformitarian doctrine.

Present thought assumes the energy to come from decaying radioactive materials. But even this source is essentially a declining and non-renewable resource.

A captured segment of a comet's tail, on the other hand, relies only on the earth's mass as its energy source. Gravity captures the tail segment, guides its spiral descent, and shapes the triangular profile of ridges. The lighter elements are transported by the same energy source down to the sea, leaving the great fossil-filled layers of sediments behind, stacked up in kilometre deep strata.

CONCLUSION: BACK TO THE "PENULTIMATE SILICATE FROTH"

Ultimately, the Uniformitarian view of the earth's surface is that of a parent looking at the vestiges of a birthday cake. The parent is trying to bring back the image of the pristine condition of the layered confection before it was ravaged by the children.

The exogenist takes the cake's remains as the principal evidence available to understand the narrative of the earth's geological history.

Sir Henry Howorth, in his 1905 work, 'Ice or Water', found the absence of significant erosion in the earth's sedimentary strata fatal to the conventional idea of an upwardly generated planetary crust. This was his challenge:

" . . . [What] we want to see is a plain instance of valleys excavated and mountains formed in the ancient strata of the earth as we find them existing in the present day…until then we take leave to reject the theory . . . the parallelisms of the beds over large regions of the earth stand in complete opposition (to the notion that the under strata have ever been the surface of the earth for indefinite periods.)" [51]

In reporting on the results of the Glomar Challenger drilling program, Skinner made a telling remark on the nature of mountain belts:

"Crustal rocks appear literally to be a penultimate silicate froth of the most uncommon terrestrial elements..." The writer concludes, "Because the earth and oceans and air are extreme distillates and fractionates of the average original earth and very unlike it in

composition and origin, it is obviously risky, if not misleading, to infer that superficial studies tell much of what we must know of time in the earth." [19]

We could not agree more with Skinner's statement, and go one step further and declare that the "penultimate silicate froth" tells us little of "time in the earth", precisely because it does not originally belong to the earth, and is therefore necessarily "very unlike it in composition and origin".

Both Skinner, a believer in plate-tectonics, and Howorth, who believed the earth's topography the product of great floods, would have been offended by the use made of their statements, for they were both essentially endogenists. But if we wish to go with the principle of always looking at the empirical evidence, it should allow us to regard this "penultimate silicate froth" as the key to understanding our geological past.

REFERENCES

[1] Newton, Isaac. *Philosophiæ Naturalis Principia Mathematica*. Berkely: University of California Press, 1934.

[2] Zysman, Milton, and Frank Wallace. "Tails of a Recent Comet: The Role Cometary Jets Play in Crustal Formation." *The Society for Interdisciplinary Studies Cambridge Conference: Natural Catastrophes during Bronze Age Civilizations, 11-13 July 1997*. http://arxiv.org/abs/1004.0416

[3] McCrosky, Richard E. "Comet." *The Sun and Solar System Debris: A Catalog of Astronomical Anomalies*. Ed. William Corliss. Glen Arm: The Sourcebook Project, 1986. 69-70.

[4] Reach, William T., Michael S. Kelley, and Mark V. Sykes. "A survey of debris trails from short-period comets." *Icarus* 191.1 (2007): 289-322. http://arxiv.org/abs/0704.2253

[5] "Comet." *The New Encyclopaedia Britannica, 15th Edition*. Chicago: Britannica, 1986.

[6] Maddox, John. "Halley's comet is quite young." *Nature* 339.95 (1989): 95-96.

[7] Sekanina, Zdenek. "Solar and Heliospheric Observatory Sungrazing Comets with Prominent Tails: Evidence on Dust-Production Peculiarities." *The Astrophysical Journal* 545.1 (2000): L69-L72. http://www.iop.org/EJ/article/1538-4357/545/1/L69/005752.html

[8] *Saturn's Moon Iapetus – Explore the Cosmos*. The Planetary Society. 17 Aug 2009 http://www.planetary.org/explore/topics/saturn/iapetus.html

[9] Ip, Wing-Huen. "On a ring origin of the equatorial ridge of Iapetus." *Geophysical Research Letters* 33.L16203 (2006).

[10] Zysman, Milton. "Sediment." *Catastrophism 2000: A Sourcebook for the Conference Reconsidering Velikovsky*. Eds. Zysman, Milton, and Clark Whelton. Toronto: Heretic Press, 1990. 95-137.

[11] Reinhard, R. "The Giotto mission to comet Halley." *Journal of Physics E: Scientific Instruments* 20.7 (1987): 700-712.

[12] Sekanina, Z., and J.A. Farrell. "The Striated Dust Tail of Comet West 1976 VI as a Particle Fragmentation Phenomenon." *The Astronomical Journal* 85.11 (1980): 1538-1554. **http://articles.adsabs.harvard.edu/full/1980AJ.....85.1538S**

[13] Boehnhardt, H. "Split Comets." **http://www.lpi.usra.edu/books/CometsII/7011.pdf**

[14] Lyell, Charles. *Student's Elements of Geology*. London: John Murray, 1875.

[15] Droser, Mary L., Richard A. Fortey, and Xing Li. "The Ordovician Radiation." *American Scientist* 84.2 (1996): 122-131.

[16] "Rock." *Random House Webster's Unabridged Dictionary*. 1997.

[17] Tilling, Robert I. *Volcanoes: USGS General Interest Publication*. United States Geological Survey, 1985.

[18] Geological Society of America Special Edition, the history of Appalachian orogenetic theory.

[19] Skinner, Brian J., ed. *Earth's History, Structure and Materials - Readings from American Scientist*. Los Altos: William Kaufmann Inc., 1982.

[20] Hart, Stanley. *Geochemical Evolution of the Mantle*. 1 Dec. 2001. Science Storm. **http://www.sciencestorm.com/award/0125917.html**

[21] Pittichová, J., Z. Sekanina, H. Boenhardt, K. Birkle, D. Engles, and P. Keller. "An Early Investigation of the Striated Tail of Comet Hale-Bopp (C/1995 O1)." **http://trs-new.jpl.nasa.gov/dspace/bitstream/2014/22870/1/97-1409.pdf**

[22] Sekanina, Z., and J.A. Farrell. "Evidence for Fragmentation of Strongly Nonspherical Dust Particles in the Tail of Comet West 1976 VI." *Solid Particles in the Solar System: Symposium No. 90 Organized by the IAU*. Eds. Halliday, I., and B.A. McIntosh. New York: Springer-Verlag, 2002.
http://articles.adsabs.harvard.edu/full/1980IAUS...90..267S

[23] Sekanina, Zdenek, Emmanuel Jehin, Hermann Boehnhardt, Xavier Bonfils, Oliver Schuetz, and Daniel Thomas. "Recurring Outbursts and Nuclear Fragmentation of Comet C/2001 A2 (LINEAR)." *The Astrophysical Journal* 572.1 (2002): 679-684.
http://www.iop.org/EJ/article/0004-637X/572/1/679/15999.text.html

[24] Prange, R., I. Engle, M. Dunlop, M.K. Dougherty, S. Maurice, W.H. Ip, J.T. Clarke, and G.E. Ballester. "Magnetic mapping and interpretation of auroral signatures of Comet SL9 in the jovian magnetosphere." *IAU Colloquium 156*.

[25] Hughes, D.W. "The size, mass, mass loss and age of Halley's comet." *Royal Astronomical Society Monthly Notices* 213 (1985): 103-109.
http://articles.adsabs.harvard.edu/full/1985MNRAS.213..103H

[26] Oltean, Marius. "On the feasibility of applying presently understood cometary fragmentation processes to the Zysman-Wallace hypothesis."
http://books.google.ca/books?id=eUl1dWVcE2UC&dq

[27] Malkki, E. "Ground-water flow velocity as an indicator of the permeability and internal structure of eskers." *Vesientutkimuslaitoksen Julkaisuja 32*.

[28] Nishioka, Kimihiko. "Finite Lifetime Fragment Model 2 for Synchronic Band Formation in Dust Tails of Comets." *Icarus* 134.1 (1998): 24-34.

[29] Birkle, K., O. Ryan, H. Boehnhardt, Z. Sekanina, D. Engels, P. Keller, and M. Jaeger. "Dust Tail Striae in Comet Hale-Bopp." *Astronomische Gesellschaft Meeting Abstracts, Abstracts of Contributed Talks and Posters presented at the Annual Scientific Meeting of the Astronomische Gesellschaft at Heidelberg, September 14-19, 1998*.

[30] *How many rings are there?* Cassini Teacher's Guide Q&A to Saturn.
http://www.jpl.nasa.gov/cassini/educatorguide/questions_answers.pdf

[31] Staedter, Tracy. "Jupiter's Gossamer Rings." *Astronomy* Jan. 1999.

[32] Spencer, John R., Amy C. Barr, Larry W. Esposito, Paul Helfenstein, Andrew P. Ingersoll, Ralf Jaumann, Christopher P. McKay, Francis Nimmo, Carolyn C. Porco, and J. Hunter Waite. "Enceladus: An Active Cryovolcanic Satellite." **http://www.es.ucsc.edu/~fnimmo/website/enceladus_revised_sm.pdf**

[33] Campbell-Brown, Margaret. "The Meteoroid Environment: Shower and Sporadic Meteors." *Workshop on Dust in Planetary Systems (ESA SP-643), September 26-30, 2005, Kauai, Hawaii*. Eds. Krueger, H., and A. Graps. Huston: Lunar and Planetary Institute, 2005. **http://www.mpi-hd.mpg.de/dustgroup/~graps/dips2005/120_CampellBrown_FINAL.pdf**

[34] Zysman, Milton. *Unraveling Genesis*. Toronto: Heretic Press, forthcoming 2011.

[35] Olmstead, Denison. "Observations of the meteors of November 13th, 1833." *American Journal of Science* 25 (1833): 354-411, 26 (1834): 132-174.

[36] Velikovsky, Immanuel. *Worlds in Collision*. New York: Doubleday & Company Inc., 1950.

[37] Reach, William T., Jeremie Vaubaillon, Michael S. Kelley, Carey M. Lisse, and Mark V. Sykes. "Distribution and properties of fragments and debris from the split comet 73P/Schwassmann-Wachmann 3 as revealed by Spitzer Space Telescope." *arXiv:0905.3162* May 2009. **http://arxiv.org/abs/0905.3162**

[38] Ishiguro, Masateru, Fumihiko Usui, Yuki Sarugaku, and Munetaka Ueno. "2006 Fragmentation of Comet 73P/Schwassmann-Wachmann 3B Observed with Subaru/Suprime-Cam." *arXiv:0904.4733* Apr 2009. **http://arxiv.org/pdf/0904.4733v1**

[39] "Mountain." *Random House Webster's Unabridged Dictionary*. 1997.

[40] Buddhaghosa, Bhadantacariya and Bhikkhu Nanamoli. *Visuddhimagga*. Pariyatti Publishing, 2003.

[41] "Geochronology." *The New Encyclopaedia Britannica, 15th Edition*. Chicago: Britannica, 1986.

[42] Ehlers, Ernest G. and Harvey Blatt. *Petrology: Igneous, Sedimentary, and Metamorphic.* San Francisco: W.H. Freeman and Company, 1982.

[43] Daly, Reginald. *Earth's Most Challenging Mysteries*. Grand Rapids: Baker Book House, 1972.

[44] Darwin, Charles. *On the Origin of Species*. New York: Oxford University Press, 1996.

[45] Flint, Richard Foster. *Glacial and Pleistocene Geology*. New York: Wiley, 1957.

[46] Corliss, William. *Anomalies in Geology: Physical, Chemical, Biological.* Glen Arm: The Sourcebook Project, 1989.

[47] Penniston, J.B. "Note on the Origin of Loess." *Popular Astronomy* 39 (1931): 429-430.

[48] Pratt, David. "Plate Tectonics: A Paradigm under Threat." *Journal of Scientific Exploration* 14.3 (2000): 307-352.

[49] "The Theory of Plate Tectonics." *Encyclopaedia Britannica*. 2010. Encyclopaedia Britannica Online, **http://www.britannica.com/EBchecked/topic/176118/Earth-sciences/60427/The-theory-of-plate-tectonics**.

[50] Kious, Jacquelyne and Robert Tilling. *This Dynamic Earth: The Story of Plate Tectonics*. US Geological Survey, 2001.

[51] Howorth, Henry. *Ice or Water*. London: Longmans, Green and Co., 1905.