CONTINENTAL DRIFT:

Is It A Cometary Impact Phenomenon?

Allan O. Kelly.

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BY
ALLAN O. KELLY

CARLSBAD, CALIFORNIA.
October 22, 1963.
Revised:
December 1966.

All pictures courtesy of Mt. Wilson Observatory unless otherwise noted

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FOREWORD

This monograph is the out-growth of several years of reading, research and friendly debate about one of the most interesting and exciting problems of earth history, namely, the cause or causes of continental drift.

My first interest in this subject came in the early nineteen-forties and gradually increased in the latter part of that decade when the writing of a manuscript entitled Cosmic Collision Geology was undertaken. Nothing came of this effort until 1951 when Dr. Frank Dachille, then a research chemist at Pensacola, Florida, happened to read an old article of mine that appeared in the December 1947 issue of POPULAR ASTRONOMY. It was called The Geology of the Moon. He became interested in the subject of collision geology and we started a correspondence that ended in the publication of a co-authored book under the new title of TARGET: EARTH, privately published in 1953. This book was not taken seriously at the time but it did contain many original ideas including the idea that island arcs were the product of massive meteorite collision and that minor drift of the arcuate rim was a feature of such collisions.

In 1955 I was asked to give a paper on the origin of the island arcs at the Western Amateur Astronomer's Convention, held that year in Yosemite Valley, California, and in 1957, the same paper was given before the geological section of the American Association for the Advancement of Science, which met that year in Tucson, Arizona.

In 1962, at the third annual Periscopium on Meteoritics held at Carlsbad, California, I first suggested the possibility that a very large cometary collision on the Pacific side of the earth, might have caused the continental drift features as seen in the Mid Atlantic Ridge and its matching continental outlines. I also placed on display at that meeting, a large scale aerial map of the Hudson Bay Arc and pointed to the possibility that the Belcher Islands and the Nastapoka Island chain, might have been the product of collision in which strips of the crater rim broke away and drifted on a pool of molten magma. This second speculation aroused considerable interest among those present.

At the fourth Periscopium held at Pennsylvania State College in October 1963, continental drift was a frequent topic of conversation and a paper proposing convection currents as a possible cause of continental drift was presented by Dr. Robert S. Dietz. It was apparent from the discussion that most of the scientists there agreed that convection currents were the most probable cause of continental drift. Since I could not agree with this theory, I determined to begin a more thorough study of cometary collision as the source of power. Here, it seemed, one might discover actual physical evidence on the surface of the earth, evidence far more susceptible to proof than speculations about convection cells in the interior of the earth. It must be remembered that all evidence for convection currents or any other dynamic force that might have moved the continents, must rest its case upon physical evidence found on or near the surface of the earth. It is the interpretation of the evidence that is controversial. The geologist tends to interpret it as diastrophic movement (convection currents) coming from

the interior of the earth because this is what he has been taught to believe, and the astronomer, who long ago abdicated his right to study the earth as a planet, sits by in silence. This is not his field.

This bowing to convention by the professionals, opens the door to the non-professional scientist who may be well-versed in several branches of natural history and who has no code of ethics or professional standing to maintain. He is, therefore, in a position to step over the dividing lines between scientific disciplines, to speculate and to synthesize in a way that might be considered un-scientific or unethical in professional circles. There is, however, a move away from this long established trend as seen in the title of the presidential address of Dr. Peter M. Millman at the meeting of the Meteoritical Society, November 1966, in Washington D.C. The title "LINES AND SQUARES" was taken from the well known children's poem by A. A. Milne and was a plea for a wider outlook and a crossing of lines between scientific disciplines. It is to be hoped that this trend will continue.

Finally, I wish to acknowledge the kindness and consideration of those busy scientists who took the time and trouble to read the first draft of this manuscript and to return their constructive criticisms. I am especially indebted to Dr. C. S. Beals, Director of the Dominion Observatory, Ottawa, Canada; to Dr. Ralph B. Baldwin, astrophysist of Grand Rapids, Michigan and to Dr. Frank Dachille, Associate Professor of Geochemistry at Pennsylvania State College who has been a long-time friend and fellow worker in this field of scientific investigation.

Carlsbad, California.
January, 1967.

Allan O. Kelly

Carlsbad, Calif.
August 22, 1966

CONTINENTAL DRIFT: IS IT A COMETARY IMPACT PHENOMENON?

Historical Background

Continental drift, that most fascinating of earth mysteries, is rising again on the currents of scientific thought. Leaders in the various fields of earth science are giving it an increasing share of their attention, for the physical evidence is so strong and clear that it can hardly be ignored, besides, little if any negative evidence is to be found. The big problem seems to be the source of power. What caused the continents to drift? Was it done by convection currents from within the earth, by gravitational forces, or by impact from without? So far, we have only these three forces.

The theory of continental drift is said to have been first proposed by Antonio Snider, a Dutch geographer who had noticed the matching lines of South America and Africa, but the first real study was made by the German geologist, Alfred Wegener, in the early years of the 20th Century. An American geologist, F. B. Taylor, had published a paper at about the same time without knowing of Wegener's work but it was of little import compared with the years of study given to the subject by Alfred Wegener. Wegener believed that all of the continents had at one time, been a single mass. He spent many years gathering evidence to show that now distant coast lines had once been joined and he pointed to much good evidence to prove his case but he was never able to offer any reasonable source of energy to have caused the drift. Lacking an acceptable source of energy and the important supporting evidence of the Mid Atlantic Ridge, then unknown, interest in the subject faded.

After World War Two, when echo sounding came into general use oceanographers were not long in searching out and mapping the Mid Atlantic Ridge and, immediately, continental drift took a new lease on life. This great undersea mountain range was found to follow the median line between the continents nearly half way around the world; from Iceland down through the North Atlantic and the South Atlantic it continued toward the Antarctic Continent, turning east about 1,000 miles short of Antarctica and following around Africa and up through the Indian Ocean to the tip of India, a distance of over 16,000 miles. Thus was found one of the most remarkable features on the face of the earth and one that most certainly must have had its origin along with the continents it so equally divides. It was found to have another significant feature too, a rift valley running through a great part of its length that forms a trough some twenty miles wide and nearly two miles deep. (See photo No. 1)

Most students of continental drift agree that the Mid Atlantic Ridge must be the starting line, the crack in the earth's crust from which the continents drifted. The physical evidence could hardly be more clear but finding the motive power has been a far more difficult matter.

At the present time there are probably only two schools of thought, those who look to forces coming from within the earth and those who look to outward forces.

The convection current advocates envision huge convection cells in the earth's mantle, wherein hot magma slowly rises to the underside of the crust. Here, it is supposed, the current divides and flows in opposite directions until it cools somewhat and sinks again into the mantle, thus completing a cycle. The frictional drag on the under-surface of the crust is given credit for having broken the crust and caused the continental masses to drift apart. Speeds of one to five centimeters per year have been suggested as reasonable, and radio-active elements within the mantle have been offered as the source of heat that produced the convection currents. The time element is vague, something less than 200,000,000 years has been suggested with the thought that the drift began in Permian time. Bascom pointed out that if a crack opened in the crust to widen and form the Atlantic Ocean that no sediments on the Atlantic floor could be older. It can also be shown that at three centimeters per year the continents would have separated by a distance of 2,840 miles in 150,000,000 years. This is reasonably close to the average width of the Atlantic but it does not prove that the continents moved at this speed or any other speed.

The convection hypothesis sounds quite reasonable until one begins to think about some of the problems involved:

1. How shall we arrange convection cells within the mantle of the earth to account for the different movements of the continents?
2. How shall we draw a diagram showing two or more convection cells at work inside a sphere?
3. Are convection cells of symmetrical shape?
4. Can convection currents begin to operate within the mantle under the law of the conservation of angular momentum?
5. Why did nearly all of the drift occur on the Atlantic side of the earth and not on the Pacific side?
6. Is it reasonable to suppose that all of the radio-active heat was generated in the Atlantic half of the mantle?
7. If the earth's crust is a rigid sphere or shell, could segments of that crust drift in any direction without over-riding other sections of the crust or pushing it up into mountain folds equal to the distance traveled?
8. Why did all the continents drift toward the Pacific basin?
9. If convection currents were in operation from the beginning of time how did the crust manage to form?
10. Why should convection currents continue to operate after a crack opened in the crust? Would not the heat then have dissipated through the opening and the cell ceased to function?

These are a few of the questions that may be asked.

The second school of thought which looks to extra-terrestrial forces, finds itself with two possible explanations, gravitational disruption and meteoritic or cometary impact.

PHOTO NO. 1

The Atlantic hemisphere of the earth showing the Mid Atlantic Ridge and paralleling continents of Africa and South America. Reproduced from LIFE'S "A NEW PORTRAIT OF OUR PLANET." Published in 1960 by TIME INC.

Gravitational disruption brings to mind at once, the old-time theory that the moon was born of tidal disruption when some large body came too close to the earth and pulled a large mass away from the Pacific hemisphere. Whatever the possibilities or improbabilities of this hypothesis, it points up the strong possibility that such a disruption might crack open the crust of the earth on the opposite side and cause the continental masses to drift toward the area of disruption.

The second possibility, meteoritic or cometary impact, seems far more logical and probable than gravitational disruption, but here again, we have alternatives, two known types of striking bodies, comets and asteroids. Which is the more probable agent judging from the evidence on the earth and on the moon?

At this point it should be mentioned that gravitational disruption and convection currents are about on a par, there being no solid proof that either event has ever occurred. They are simply speculations derived from physical evidence we see on the earth. Meteoritic or cometary impact is a far different matter. We know that comets and asteroids are circulating through our solar system; passing stars of disruptive gravitational size are unknown so why speculate about a force so vague and uncertain?

Cosmic collision is a known fact. This was brought out clearly in a recent article called "The Martian Surface" by E. J. Opik in SCIENCE, 15 July 1966. I quote: "Attempts to ascribe a volcanic origin to the Martian features can be ignored completely. Whether there are volcanic formations on the moon or Mars remains to be proved; some inconspicuous lunar objects are indeed suspected of being of volcanic origin. The lunar and Martian craters bear close resemblance to terrestrial meteor craters and are very different in structure from terrestrial volcanoes and calderas. Meteor craters are both an observational and a statistically predictable fact." If Dr. Opik had cared to speculate, he might have added that volcanoes are probably the best physical evidence that massive collisions have occurred on the earth and that they are very likely the final adjustment mechanism by which gravitational and rotational forces bring the earth to a more perfect equilibrium.

Cosmic collision, then, is not a hypothesis or a theory but a fact. A fact basic to the Universe itself, for whole galaxies are known to be in collision and only recently photographs were released from Mt. Palomar Observatory showing what they supposed to be a cataclysmic explosion in M-82, one of the millions of galaxies in our Universe. (See photo No. 2) While the greater part of such an explosion may generate only high velocity ionized gases there must be some solid matter created from these cataclysms, whether by gravitational disruption or by impact, for we know that large chunks of solid matter *are* circulating through some areas of our solar system. The very fact that they exist proves collision and possibly, tidal disruption. (See photo on back cover and on page 74A)

While cosmic collision is now a known and proven fact, it was quite unknown when geological science was first organized and for a long time thereafter and because old and well established ideas die hard, the theory of Uniformity, propounded by Hutton and his followers is still much in vogue after 180 years. After so many years of teaching that all

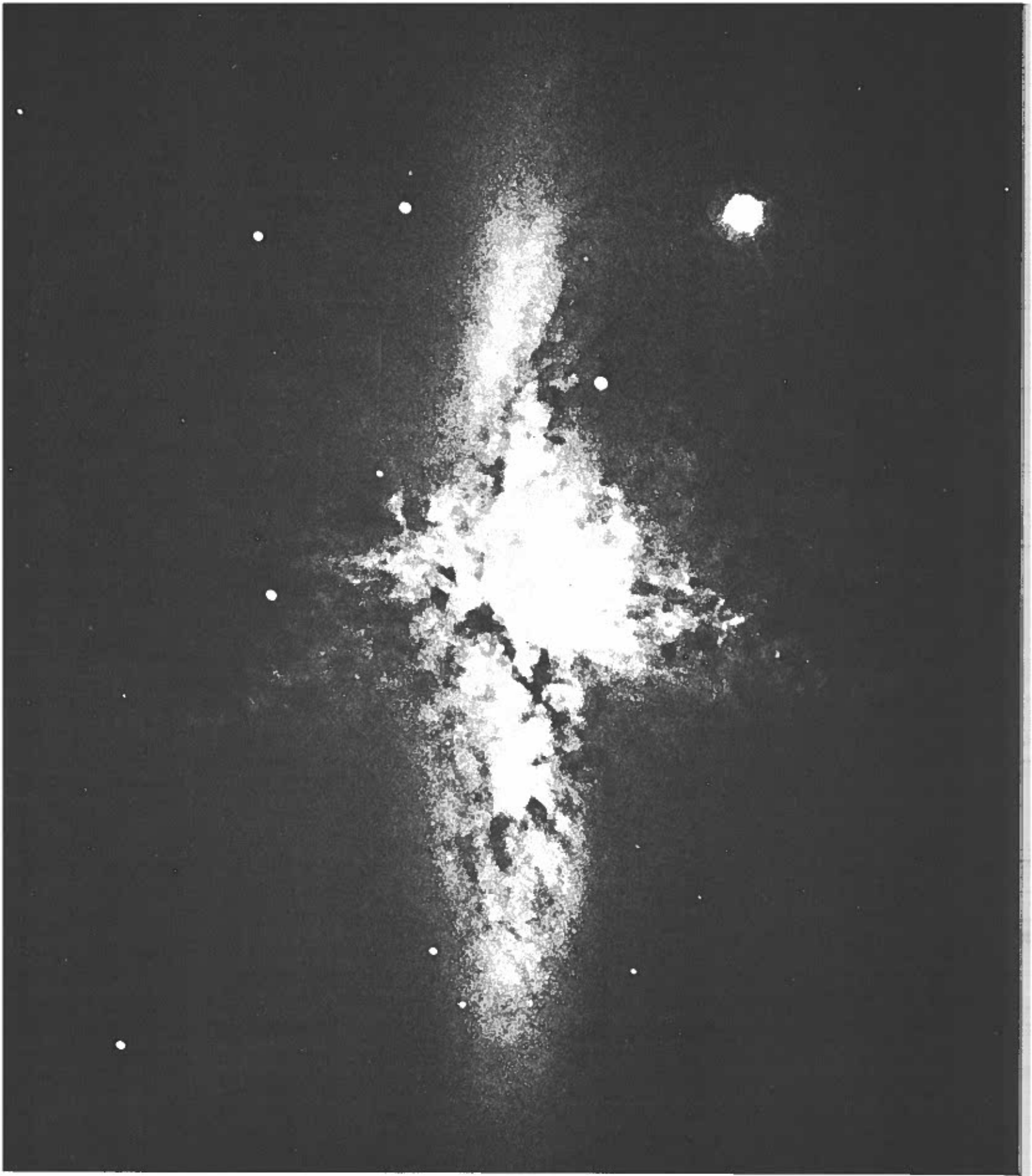


PHOTO NO. 2

Mt. Palomar photograph of the supposed cataclysmic explosion of a galaxy known as M-82.

dynamic forces affecting the surface of the earth originate within the earth, it is not easy to establish a new concept, especially one in complete opposition.

It is the purpose of this paper to cite whatever physical evidence seems to support the idea that massive sections of the earth's crust have drifted on the heavy magmas of the mantle. It is our thesis that all of the physical evidence points to a gigantic collision, by far the greatest and most violent the earth has ever experienced; one which turned the Pacific hemisphere of the earth into a basin of molten magma into which the continents could drift. A continuous crust would have prevented continental drifting and without the cosmic punch on one side, no drifting could have occurred.

Such a hypothesis as here proposed, must be outlined in great detail and physical evidence of every kind must be brought to bear, if the idea is to be anything more than sheer speculation. Perhaps the strongest criticism of the convection current theory is that its advocates fail to go into detail. They usually draw a circle for the earth, add a simple convection cell and then plunge into a sea of geochemistry and mathematical assumptions. This is a colossal problem and its solution would seem to come more logically from a study of its colossal physical features and facts. Rather than start with a theory and try to make the physical facts fit the theory, we should look first at the physical facts and try to formulate a theory that will fit them. What do they indicate as to force? Was it exceeding fast or exceedingly slow? Which force can be proved by observation? Can anyone prove or *disprove* that a whole continent has moved as little as 5 centimeters per year? Obviously not. Calling upon immeasurably slow forces acting through immeasurably slow time is pure, undiluted, speculation. Its only merit lies in the fact that it cannot be disproved. All of the great and massive forces of the earth act quickly whether tidal action in the sea or land, volcanic eruption or earthquake, and all have their source of power, or have *had* their source of power, from outside the earth. Since the earth was formed by accretion the heat energy within the earth is stored energy. The radioactive energy assumed by the advocates of convection currents is sheer speculation. It cannot be proved or disproved. All this is not to say that extremely slow continental movements do not take place but only that the original source of energy came from the impact of massive bodies. The continental masses, the ocean basins and many of the lesser earth features could not have derived from the accretion of dust and solid chunks of matter no larger than that which made the Arizona Meteor Crater. The physical evidence points to many massive collisions. Most of these no doubt occurred in Precambrian time and some even in very recent time but the greatest of all occurred when the Pacific Basin was formed and the continents began to drift. The fact that all of the continents began to drift at the same time indicates that the cause was from a single event, not a series of convection cells that became active from time to time.

If we study the undersea topography of the Pacific Basin we find a broad belt of islands, undersea mountain ranges and individual seamounts whose general trend is from WNW to ESE across the Equator from the coast of China to the coast of Chile. At the western end along the coast of Asia, we find a number of large island arcs and oceanic trenches that cut across this belt at right angles, indicating, we suspect, the major collision scars of the cometary

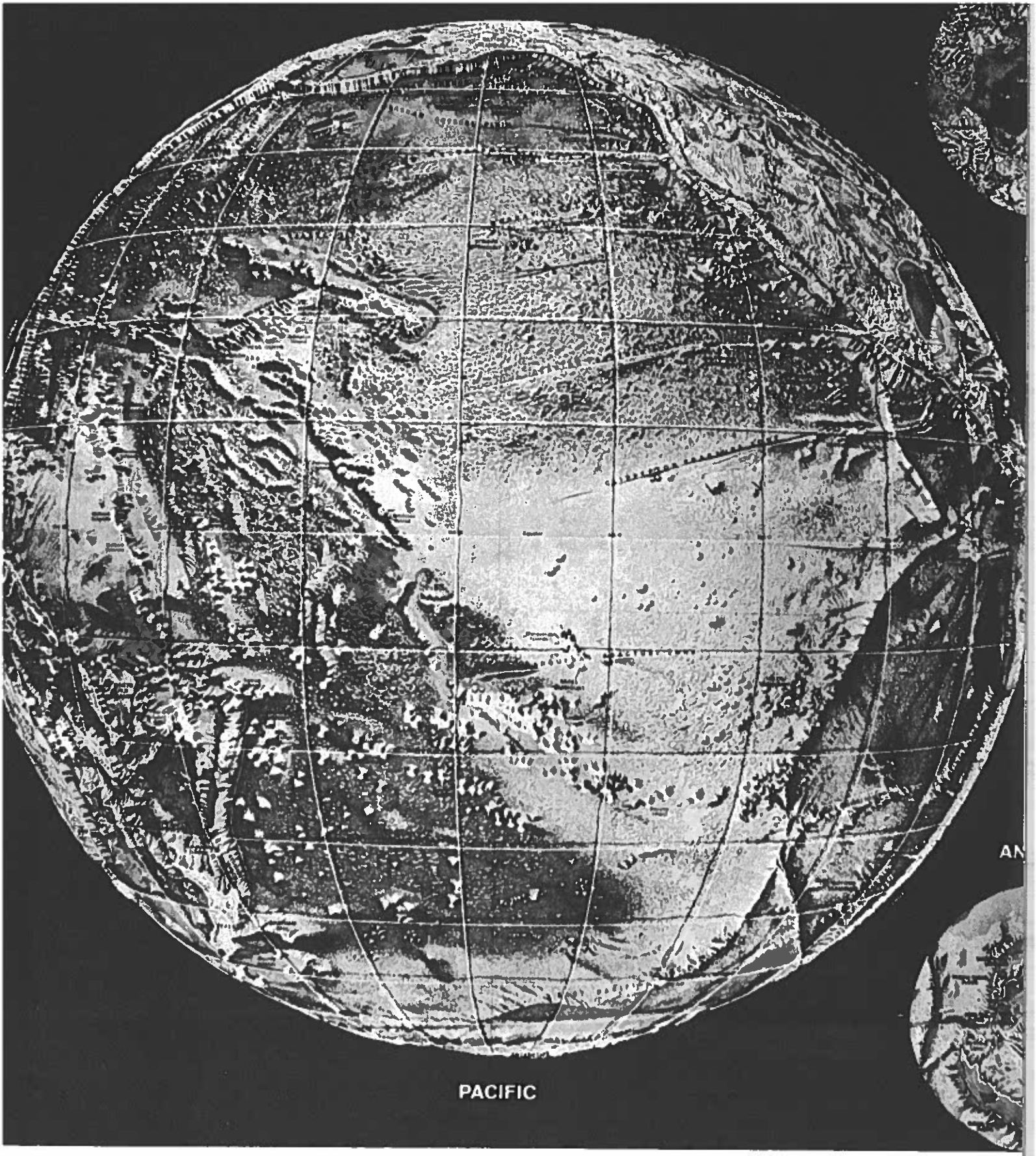


PHOTO NO. 3

The Pacific hemisphere of the earth showing the submerged mountains, fault scarps, and trenches. Reproduced from LIFE'S "A NEW PORTRAIT OF OUR PLANET." Published by TIME INC., 1960.

train. (See photo No. 3)

If we postulate a cometary train containing a dozen or more bodies of asteroidal size, together with thousands of smaller chunks of iron, rock, ice and other debris, striking the earth in a series of slightly delayed shocks as the earth turned under this stream, then perhaps we have a source of energy sufficient to not only cause the continents to drift but to melt the whole Pacific side of the earth and remove the rigid crust that would otherwise have prevented drifting. The delayed impacts might also have prevented total disruption of the earth, especially, if we suppose the cometary train to have come from the rear and at a downward angle. Since the earth moves at 18 mps in its orbit and since the average speed of meteorites and comets is a little less than 26 miles per second, a striking speed of 6 to 8 miles per second would be possible and would therefore allow several minutes for the bombardment to continue. A single asteroid of the same total mass would probably have disrupted the earth.

One could, of course, assume many different angles of attack, different masses and velocities, different lengths of cometary train and other assumptions, but all would be assumptions. Many readers will no doubt disagree with the ones above and if this leads to some positive thinking, so much the better. My purpose is to try and point out physical features on both the earth and moon that indicate massive collisions, collisions of different scales of magnitude and under different physical conditions.

The reader should try and visualize a series of tremendous impacts on the Pacific side of the earth beginning at the coast of Asia and continuing across what is now the equatorial Pacific to the coast of South America, literally melting one whole side of the earth. The combined shocks from this terrific bombardment traveled through the earth and cracked open the crust on the other side, causing the continental mass so divided to drift away in different directions toward the area of impact. The Mid Atlantic Ridge probably represents the main fracture where the lava came up as the two sides separated and slowly drifted apart. (See photo No. 2)

THE GREAT AFRICAN RIFT

The Great African Rift is quite apparently, a secondary fracture in the earth's crust, as compared to the Mid Atlantic Ridge. (See figure No. 1). Including a number of short branches, it is some 7,500 miles in length and throughout that length, it takes many different physical forms. In some sections like the Red Sea, the Adriatic and the Gulf of Aden, and the deep African trough lakes the Rift seems to have only partly closed while in other sections the sides have closed again and squeezed the lavas to the surface. In some of these sections it slumped down to form trough valleys or circular depressions like the Ngorongora Crater. In other sections the Rift cuts across high plateaus of granitic rocks with scarcely a break in the landscape other than the 20 mile-wide band of parallel faults that reveals itself as lava cliffs a few tens of feet high. In still other sections, these parallel faults may be replaced by a single escarpment 1,500 to 3,000 feet high. (See photo Nos. 4, 5, 6, 7). The fact that these rift features cut across the Permian glaciation of the whole South African plateau is very significant for it probably indicates that this cataclysmic event was the one that brought the Permian era to a close. The Permian has long been recognized in geologic history as the period of greatest orogeny (mountain building) and climatic change in all of the earth's history since the end of Precambrian time. The extinction of vast numbers of land and marine animals took place at this time and continental glaciation ceased in the southern hemisphere along with world-wide changes in climate. (See THE EARTH by Dunbar, World Pub. Co. 1966) "The most remarkable feature of the Permian glaciation was its distribution. It led to the theory, still under debate, that the southern land masses are parts of a great continent that in Permian time occupied the south polar region and have since drifted apart. We shall return to the theory of continental drift in the next chapter." (THE EARTH, 1966)

Dunbar also mentions the tremendous disturbances in the northern hemisphere during Permian time; the vast folding and faulting of the Appalachian region; tremendous deposits of marine sediments in the Texas Permian basin, nearly 3 miles thick; great volcanic activity in western North America all the way from Mexico to Alaska and culminating in the huge lava fields of the Columbia Plateau. He points to the Permian formations in the Grand Canyon which are the most wide-spread and grandest of all the cliff formations, and finally, that Europe and Asia were subjected to this same grand-scale Permian orogeny and deposition of sediments. (See HISTORICAL GEOLOGY)

Dunbar also points to a Precambrian glaciation in a wide band across southern Canada and in India which we shall use in a later chapter to support our contention that the Canadian Shield drifted from an ancient polar region in the now North Pacific Ocean.

Most modern authorities now place the Permian Period in the geologic time scale as extending from approximately 280,000,000 years down to 230,000,000 years ago.* They all seem to agree too, that the animal extinctions, climatic changes and mountain building took place

*Note: Dr. Eugene Shoemaker in a recent address at Arizona State University, estimated that the many small craters dotting the surface of Mare Imbrium on the moon were made in the last 250 to 300 million years and the age of the basin itself as a half billion years.

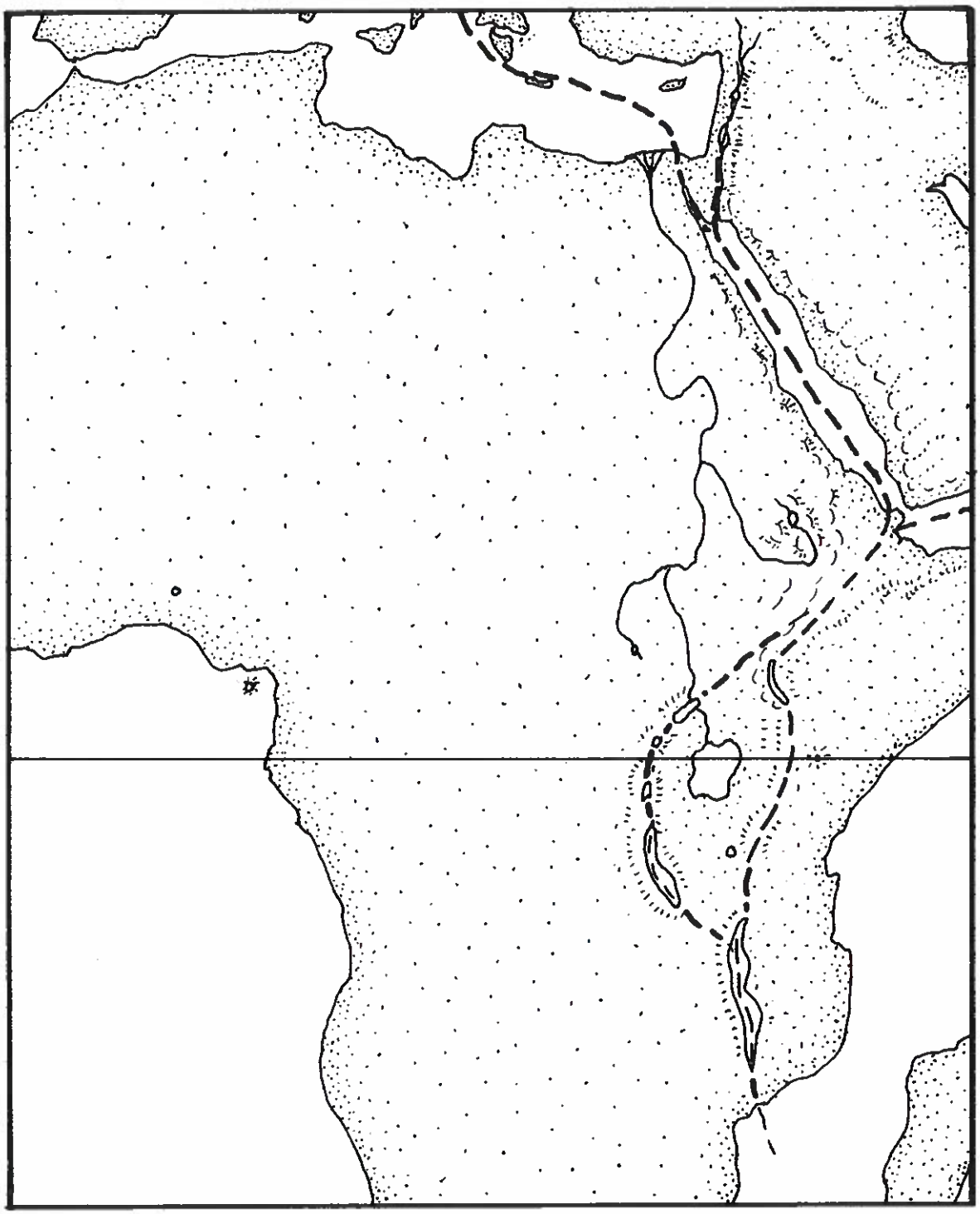


FIG. 1
Map showing extent of the Great African Rift including its branches and its division around Lake Victoria.

PHOTO NO. 4

The southeast wall of Ngorongoro Crater in Tanzania (formally Tanganyika) Africa. This crater-like depression is about 12 miles in diameter and the walls are from 1,500 to 3,000 feet in height. It is only about 20 miles west of the Lake Manyara Escarpment and it appears to be a slump feature of the same age and same cause as the African Rift.

PHOTO NO. 5

Aerial view of a small section of the African Rift showing parallel dry lake beds in the down-faulted strips. The dark lines are low lava cliffs a few tens of feet high. The strips between the dry lakes are dotted with small desert shrubs. Shadow of the wing seen in the foreground. Area of picture about a mile square.

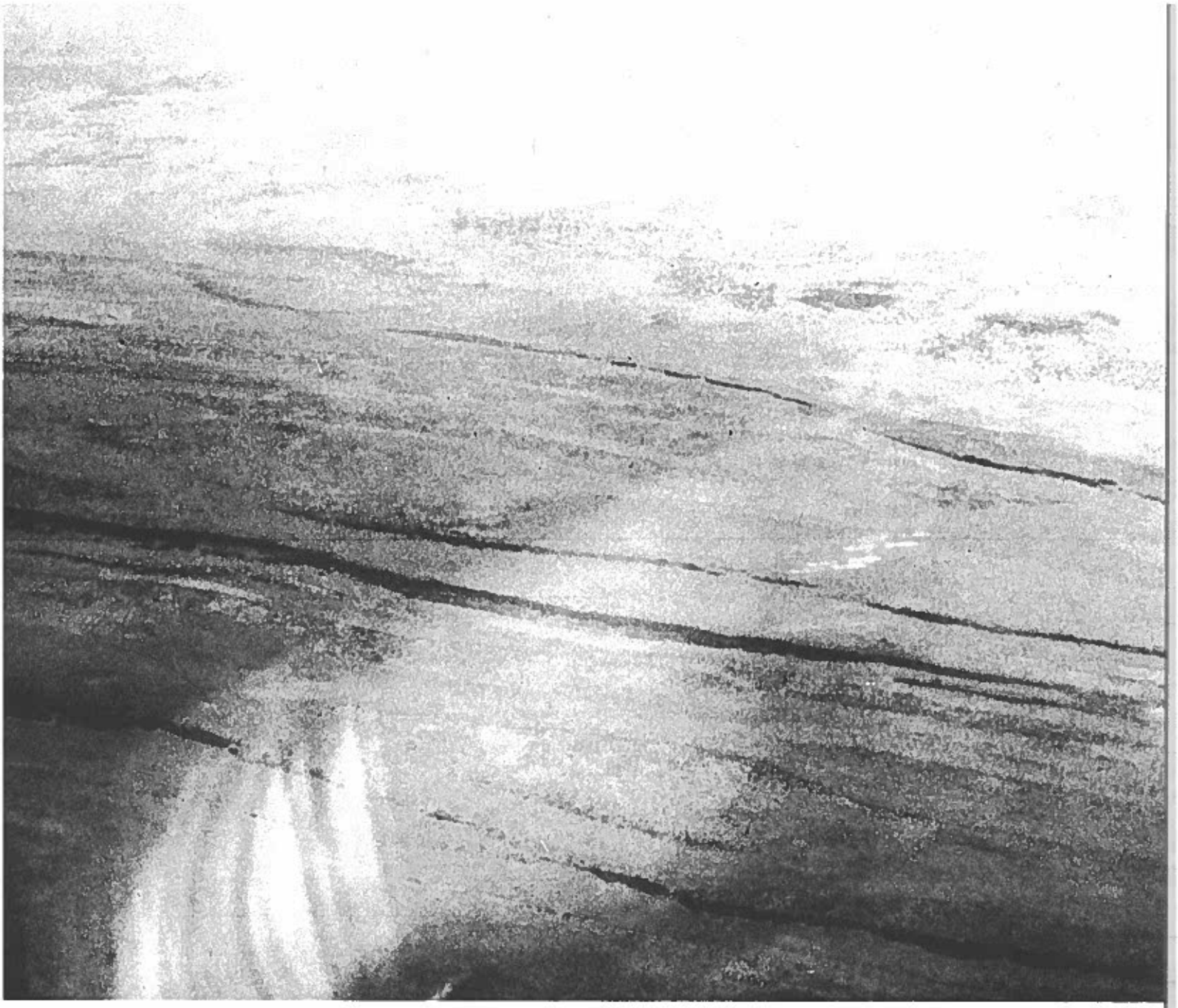


PHOTO NO. 6

A section of the African Rift in the near-level plateau country. The lava escarpments vary in height from a few feet to as much as 100 feet. The dark area marks the lava of the Rift and the upper background is the near-level granite plateau that was glaciated in Permian time. The Rift averages from 15 to 20 miles in width and the section shown here is only a mile or two wide.

PHOTO NO. 7

The African Rift escarpment near Lake Manyara, Tanzania (Tanganyika). The escarpment is about 1,500 to 2,000 feet high in this section of the Rift with little or no evidence of volcanics at the surface since it did not open up but only slumped down on the east side. The object in the foreground is an ant hill with several more just beyond.

over millions of years as a slow, uniform process. Cataclysmic hypotheses have always shocked the geologic mind, perhaps because of the prolonged controversies over the stories of the Deluge and Creation. Whatever the cause, their reasons for believing in the eternal slowness of these great natural forces, is not based upon observation or logic. As mentioned earlier, these great natural forces are known to act quickly. Whether floods, tornados, earthquakes, volcanic eruptions or the extinction of animals by disease or drought. Most biologists would probably agree that a three year continuous drought over a whole continent like Africa would kill all of the animal life that could not escape. This never happens because world climate depends upon the movement of air masses and ocean currents that are world-wide and upon the inclination of the earth's axis. Therefore, drought never occurs over whole continents in any one year. The survival of animal species over millions of years proves that this is so. Therefore when we come upon an era of mass extinctions like those of Permian time, we should not shut our minds to the possibility of cataclysmic extinction.

Returning to our cataclysmic scene in the Pacific we propose that the heat generated by the collision and by the continental masses moving over the mantle, produced an additional amount of liquid lava under the crust, and thus lubricated, they moved away toward the area of impact leaving behind a liquid sheet of magma that cooled to form the floor of the new Atlantic Ocean. At the same time the earth swelled and expanded as it absorbed the cometary mass. This new ocean floor was formed partly of the mantle and partly from the crust as it squeezed out behind the moving continent. This mixture produced an ocean floor of rocks not so heavy as those of the Pacific Basin which came from much deeper and heavier magmas. For this reason the rocks of the Atlantic floor are lighter and its basin shallower.

The whole configuration of the earth had to change too, to meet the earth's new rotational requirements and isostatic equilibrium. These changes must have taken place in the mantle, the continents coming to rest after some twisting and turning as they met the lateral pressures of the out-flowing magma on the edges of the collision pathway. All of this must have happened in a very short time and under conditions violent beyond the wildest imagination.

Most of the ocean water (probably then much less in volume) would have been converted into steam and clouds, covering the earth to great thickness. Most land and marine animals would have been exterminated over great areas of the earth's surface by this cause alone.

Considerable time would elapse before the ocean floors cooled sufficiently to allow water to accumulate. The cooling process would begin along the margins and creep inward, the great masses of polar ice hurrying the cooling to some extent. Also, the continental masses would absorb considerable heat from the superheated atmosphere and eventually bring about a continuous rain which, along with the ocean flooding, would hasten the return of the oceans to their new basins and to new heights of sea level.

But how shall we check on the soundness of these speculations?

Perhaps one of the best checks would be by means of the several new chemical age determination techniques. It is obvious, for example, that if lavas from many parts of the deep Pacific Basin, the Mid Atlantic Ridge, the African Rift, the Atlantic and Indian ocean basins

are found to be of the same age, then they must have been made by the same cause or event. Of course, lava samples from volcanoes should be eliminated because of much later origin. This might be a worthy project for the Moho drilling rig, to get short cores from the deep ocean.

Whatever the time element, we must look to the physical features of the earth as the Rosetta Stones to be interpreted, and this must be on a grand scale with the overall picture in mind. We must ask what caused all of the millions of square miles of basic lavas on the deep ocean floors, not simply assume they were there from the beginning. And what force lifted the continents and why were they eroded for millions of years before being separated by wide ocean basins?

When we examine the globe, we find a wide band of islands extending across the central Pacific, roughly, from China to Chile. This line crosses the equator near the 180th meridian in a direction roughly, northwest to southeast but then, in Permian time, more nearly from pole to pole. It is probable that more than 180 degrees of the earth's circumference was blasted but the continental masses drifted in over this area from all sides. This is indicated on the western side where five seas of circular form line the coast of Asia. Bering Sea, Sea of Okhotsk, Sea of Japan, East China Sea and South China Sea; all are deformed basins probably pushed out of their circular impact shape by the drifting Asiatic coast. The eastern boundaries of these seas are formed by island arcs which have been somewhat flattened by the lateral pressures from both east and west. It is perhaps significant that all of the deep focus earthquakes of this area, have been recorded under the basins of these seas or under the mainland behind them. (See SEISMICITY OF THE EARTH by Gutenberg & Richter, pp 55-56) The shallow shocks are all under the arcuate island rims. If these basins represent the craters of some of the largest bodies in the cometary train, then perhaps we can believe that they were deformed and partially over-ridden by the drifting continent of Asia. The deep shocks under the basin and continental edges apparently come from the slow cooling and contracting of the deep-seated magmas there, the shallow shocks *not* being recorded there because that rim of the crater was entirely removed by the edge of the continent. This may be speculation but it is based upon recorded earthquakes.

At the other end of the collision pathway we find an unusual feature in the Fijian Platform. Here we have a plateau some 500 miles in diameter rising out of the deep ocean to within a few hundred feet of the surface and scattered over it, hundreds of small islands with two large islands near the center. The mysterious condition here is that all of this vast body of basic lava has been raised off the ocean floor without benefit of volcanoes. Neither of the large islands, Viti Levu or Vanua Levu possesses a true volcano although both are topped by star shaped mountains with extending lava ridges like the arms of a starfish. All is basic lava except for a little granite near the center of Viti Levu which has been uncovered by erosion. A geologist (the curator of the museum at Suva) told me that with the exception of a caldera on a small island between the two large ones and a small volcanic cone near the southeast edge of the platform, nothing in the nature of a true volcano could be found. This, he agreed, was something of a mystery, how so much volcanic rock could have been raised off the deep ocean floor with so little evidence of volcanic craters. Geological science has usually attributed this sort of thing, widespread lava fields without apparent source, to fissure flow in which lava supposedly came up

through long cracks in the earth's crust and spread out, leaving no vissible sign of the fissure itself. One objection to this theory is that the great lava fields of the world such as the Columbia River Plateau (200,000 sq. miles) and the Decaan Plateau in India (250,000 sq. miles) would either require a great network of fissures or a lava so hot and liquid that it would flow long distances on a near level without cooling. This is not likely, for the most liquid lava man has observed is in the island of Hawaii where the result has been the building of a huge shield volcano, well rounded and over 13,000 feet high. Most true volcanoes seem to have begun in this way, forming rather flatly rounded shields that later developed into steeper peaks as the lava became more viscous. Mt. Kilimangaro in Africa, is a rather good example of this type of evolution in the life of a volcano. (See photo No. 8) With these facts in mind it would seem that a fissure flow should build into a long ridge rather than a flat plain or plateau. If island platforms and huge lava plateaus are hard to explain by ordinary vulcanism, how shall we explain the millions of square miles of lavas that make up the deep ocean floor?

It is here proposed that cometary collision melted the whole Pacific Basin and that the few active volcanoes in this basin and around its periphery are, and were, the adjustment vents by which gravitational and rotational forces have brought the earth's mass slowly back into equilibrium. These volcanic vents are few in number because the Pacific Basin was so throughly and deeply melted by the impacts that most of the stresses were relieved at that time. This is probably the reason why the great bulk of the Pacific Basin is so stable, so free from earthquakes, while around the edges of the continents and along the rims of the island arcs where cooling and shrinking are still going on, earthquakes are common. (See TARGET: EARTH, pp 98-101)

One of the important problems of seismicity is how it is possible for earthquakes to occur at great depths (as much as 400 miles deep) where pressures are known to be far in excess of those needed to crush the strongest rocks.* How can there be any voids and hence a chance for slumping or other movement to take place? One possible explanation might be that objects of asteroidal size not only melted the crust but sent shock waves ahead into the earth that produced lenses of higher density (heavier) rock than that in the surrounding area. Above this high density material, superheated lavas could have been formed that would have expanded more than the adjacent mantle and as these deeply burried hot spots cool and contract, sudden slumps occur. These are the deep shocks.

Whatever the mechanism of earthquakes, the Pacific Basin seems to have sustained some tremendous impacts, impacts that not only melted most of that side of the earth but cracked open the crust on the other side in all directions, allowing continental masses and smaller island chunks to drift toward the area of impact. The Mid Atlantic Ridge, apparently marks the main fracture where up-welling magma immediately filled the crack as the two sides moved away. The trough down the center of this submerged mountain ridge was probably caused by the magma slumping as the supporting walls on either side moved away.

Like the Pacific Basin, the deep basins on either side of the Mid Atlantic Ridge are very

*Recently, two deep shocks in South American indicating a vertical movement were discussed by Dr. Hugo Benioff in an article called "EARTHQUAKE SOURCE MECHANISMS" (See SCIENCE, 3/27/64).

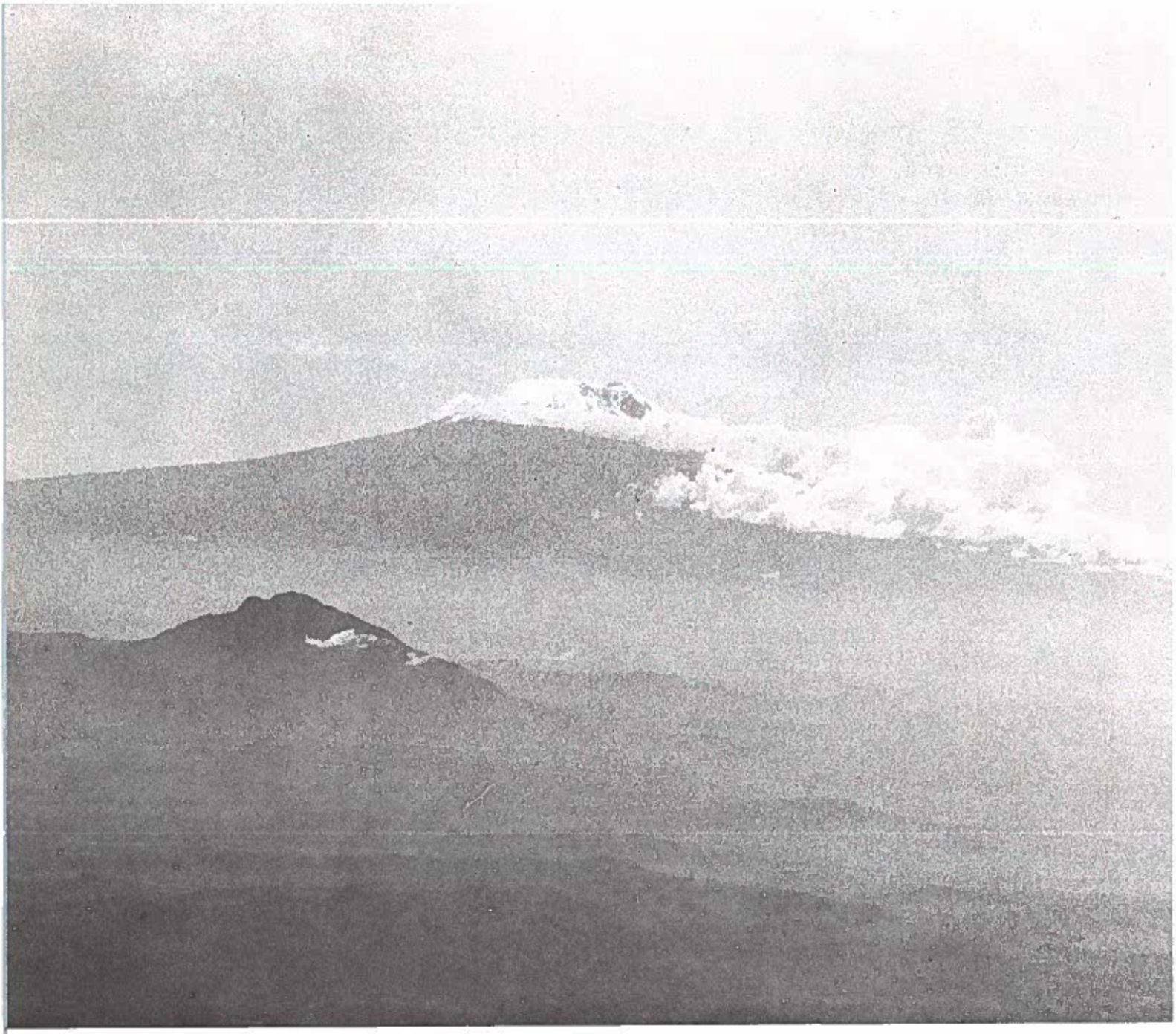


PHOTO NO. 8

Mt. Kilimanjaro, the highest mountain in Africa, rises out of a 5,000 foot plateau to a height of 19,340 feet above sea level. It is a typical shield volcano that has ended its active life with a sharply rising truncated peak when the lava became more viscous. It lies well away from the African Rift in an area of many lesser volcanic peaks.

stable and free of earthquakes. Many earthquakes do occur along the ridge but no deep or intermediate shocks have ever been recorded. Volcanoes are few in number considering the length of this submarine mountain range and most of them are grouped a little way off the main axis of the range as in Iceland and the Azores. In fact, beyond St. Peter and St. Paul Rocks, which are volcanic, no volcano appears above the surface of the ocean for the entire length of the Ridge around Africa to India, a distance of 10,500 miles. The other islands in the South Atlantic are said to be granite. In this connection it is interesting to note that there are only two volcanoes in the entire Indian Ocean. One near the Andaman Islands and the other Reunion Island, about 500 miles east of Madagascar. Madagascar itself, has none.

The volcano that is Reunion Island is one of the most spectacular sites in the world as seen from the air in the flight from Johannesburg via Mauritius to Cocos Island to Perth. It rises to 10,069 feet out of the sea in almost sheer cliffs on the eastern side with dozens of little waterfalls cutting through the ferns and mosses that cling to the cliffs. This eastern wall descends into a bay that may be a submarine crater. The top of the peak contains a huge crater perhaps 2000 feet deep and 3000 feet across; its steep walls and narrow pit indicating an explosive type of volcano. The western slope of this volcano is more gentle and supports a considerable area of sugar cane plantations and coconut groves. If Reunion Island were less remote it would no doubt be one of the scenic attractions of the world. As a geological structure rising out of an ocean basin over 18,000 feet deep it is quite unusual if not unique and will no doubt receive a great deal more scientific study in the future.

One of the interesting aspects of the Mid Atlantic Ridge and its paralleling continental masses is the break in the symmetry as seen in the Bermuda-Carribean section. This lack of symmetry we have attributed to a later collision centering in the Bermuda area and first described in TARGET: EARTH, Kelly & Dachille, pp 31-35, 1953.

Another phenomenon of the deep ocean that has been quite thoroughly explored during the past decade, is the wide, flat, structure common to the southeastern Pacific and Indian Oceans and referred to by the term "rise," "East Pacific Rise," "Darwin Rise" etc. They are among the most gigantic features on the face of the earth, 2000 to 3000 miles wide and several times as long, and usually rising to around 3000 feet above the general ocean floor. Near the top of such a rise there is often a band of high heat flow parallel to the axis and with a heat output as much as six times that of the surrounding ocean floor. Unlike the Mid Atlantic Ridge, there is no trough along the longitudinal axis but there *is* an accompanying seismic activity of shallow earthquakes. The "rises" do tend to be located in mid ocean and the East Pacific Rise parallels the coast of South America to a fair degree of accuracy. From the collision point of view, one would suspect that the East Pacific Rise is a wide pressure ridge generated by isostatic pressure from the weight of the Andes and the lateral drift pressure of the continent of South America as it came to rest following the great cometary collision in the Pacific hemisphere of the earth as outlined above. There is an excessive heat flow along the crest of these structures simply because this is the thinnest part of the crust where, along with fracture zones, the final massive adjustment of the earth's crust took place. It may be significant that these great rise features

are almost entirely confined to the South Pacific and Indian Oceans while the fracture zones are found only in the North Pacific. (See Globe) It would appear that a Rise represents a swelling of the earth to accommodate the additional cometary mass that was added and the fracture zones are isostatic adjustment features necessitated by the fact that the earth is a sphere and must develop shear faults to bring a disrupted earth to a new geodesy. The almost complete lack of volcanoes along these fracture zones indicates that this was an immediate adjustment following the collision and while the earth was still very hot, so that all strains and stresses were relieved at that time and minor volcanic adjustments were therefore, un-necessary. (See photo No. 3) In this connection, we may speculate that the hundreds of seamounts that dot the deep ocean floor between fracture zones may be shock wave rebound peaks generated by the smaller objects in the cometary train when they struck in deep ocean water. (See A WATER-IMPACT HYPOTHESIS for the SIERRA MADERA STRUCTURE IN TEXAS, by Allan O. Kelly, METEORITICS, Vol. 3, No. 2, Nov. 1966)

Note: For those who wish to get the viewpoint of orthodox geology on convection currents and continental drift, See MARINE GEOLOGY OF THE PACIFIC by H. W. Minard, McGraw-Hill, published in 1960. Another new book called STUDY OF THE EARTH, by six well known earth scientists and edited by Dr. J. F. White, takes a broader view. Continental Drift is considered from several angles and many different kinds of supporting evidence is given. The dynamics of convection currents is discussed without reaching any conclusions. Meteoritic collision is considered too, but no mention is made of the possibility that massive impact might have caused continental drift. Apparently, the geologists and earth scientists in general, are not ready to discuss earth history as a part of astronomy, or to consider the earth as a part of the solar family.

POSSIBLE DRIFT FEATURES ON THE MOON

If major cometary collision can be considered a possible cause of continental drift on the earth, then it is only reasonable to look for the same sort of features on the moon and to search out all other supporting evidence. The writer saw the possibility of a minor drift movement in the arcuate structure on the north side of Mare Crisium a number of years ago while studying the moon for structures similar to island arcs but did not see the much larger features around Mare Imbrium to be discussed later in this chapter. Mare Imbrium is the largest and most important impact scar on the moon and therefore has been given the most attention by selenographers and astrogeologists.*

Most astronomers now recognize meteoritic collision as the cause of the great majority of features on the moon including craters of all sizes, rills and maria. Some few still stick to the theory of vulcanism but not many, and there is indeed, some minor evidence of volcanic action.

Perhaps the most complete discussion of the impact theory as it relates to lunar history is to be found in a recent book called, "THE MEASURE OF THE MOON" by Dr. Ralph B. Baldwin, astronomer-physicist and executive of the Oliver Machinery Company of Grand Rapids, Michigan. This book has been called a "goldmine of references." The Author Index contains some 670 names of scientists who have made some contribution to this subject and some are referred to time and again. Baldwin not only reports the findings of others but offers many theories and hypotheses of his own, a spirit and scientific attitude that can be commended by everyone concerned.

Baldwin, in discussing the origin of Mare Imbrium and the other large maria, advances the theory that these great lava beds were first blasted out as "dry" craters and that the lava did not rise and fill them until long after the collision took place. He offers two main reasons for this delayed lava intrusion: First, he supposes that Mare Imbrium was made by a very large (100 mile diameter planetismal, moving no more than one or two miles per second that blasted out what he calls a "dry" crater, casting the debris out across the surface of the moon and "excavating valleys" radiating from the center of impact. He measures the crater made by this impact as . . . "about 421 miles in diameter, but it has been nearly buried by the later lava. Only a few isolated peaks remain to mark the moon's greatest crater." He says nothing about the depth of this crater although he infers that because of low velocity and low angle of approach, the crater was quite shallow. His second reason for delayed lava intrusion is based on the fact that the craters of Plato, Archimedes, Sinus Iridum and several smaller ones were not filled with debris thrown out by the main explosion. Hence, he says, they were made at a later date and not all at the same time, because it would be unreasonable to suppose that so many small meteorites would chance to follow a big collision while the lava was still molten. This brings him to the conclusion that all of these crater-seas were made "dry" and all filled at a much later date by lava intrusion from below. Baldwin's whole theory of "dry" craters seems to hinge about the fact that craters Plato, Archimedes and Sinus Iridum have melted floors of the same level and

*Astrogeology is a new term coined by Shoemaker & colleagues to describe their work for the U.S.G.S. in topo mapping the moon.

apparent age as Mare Imbrium. He seems very sure of this and restates it several times . . . "Without exception, it can be shown that the great circular maria were formed dry and that the lava came considerably later." (Measure of the Moon, pp 305) And again: "The crust of the moon was hard and thick when the giant circular maria were formed. These tremendous craters were formed dry. There was no extensive lava produced from the colliding body. There was no sudden release of liquid rock from below. The magmas finally appeared in these areas, but they came much later." (Page 310)

So far as I have been able to learn, Baldwin has not received any support for his "dry" theory from other scientists. He has failed to use inductive reasoning, to look for other paths and ways of explaining Archimedes, Plato and Sinus Iridum. There are other logical ways as we shall see later.

The first objection to the "dry" theory is the very low velocity (one to two miles per second) that Baldwin uses to make the theory convincing. Such a low velocity would require a following strike and while this is just as probable as any other approach, it is not likely that all the other maria were made by following strikes, if we assume as Baldwin does that they were made at different times. There is actually very little difference in the appearance of the maria and in another part of the book Baldwin quotes Shoemaker & Hackman as finding that all of the maria are about the same age, judging by the uniformity in numbers of small craters that scar their surfaces per unit area. This is good reasoning and it is our thesis that they *were* all made at the same time by a cometary train.

A second difficulty with the "dry crater" theory is how to account for the small volume of ejected material in the crater rim. Loose, angular rock along with smaller brecciated material would produce a volume of rim from 40 to 50 percent greater than if it were molten lava, yet very little rim is in evidence compared to the smaller craters on the moon. Mare Imbrium shows the most material in the rim and the other maria show little or none. There must be a reason for this and one obvious answer might be that most of the energy went to the production of lava rather than to explosive action. In this connection, Baldwin finds that the larger the striking body, the closer to the surface it explodes and that even small meteorites will not penetrate more than about twice their diameter. This being true, one would expect very little rim around such a large crater as Mare Imbrium and that, to be sloping out at a low angle. In a personal communication, Baldwin has estimated that a crater 300 miles in diameter could not have a depth of much more than 8 miles, assuming a striking velocity of 10 miles per second. This seems reasonable, and is in fact, borne out quite closely in the Gulf of St. Lawrence structure (a possible impact crater) which has been found to have a depth of sediments of nearly 4 miles against a 180 miles diameter. Of course, the gravimetric readings may reflect the lava floor of a crater that was blasted out much deeper by the actual meteoritic impact. (See Fossil Meteorite Craters by C. S. Beals et al, Dominion Observatory, Ottawa) If we assume that there is an additional 2 miles of lava above the original basement rock in this structure, we have a ratio of 1:30 and extrapolating this ratio to Mare Imbrium (without taking into consideration lesser gravitation of the moon and greater curvature of the surface) we find that Mare Imbrium

should have been about 13 miles deep as a "dry" crater.

It is very difficult to believe that craters as large as the maria could have been blasted out without the production of vast quantities of lava, not much later but almost instantly and perhaps additional lava coming up from below.

If the maria were not made by instant melting upon impact, how is it that the smaller craters (walled plains) have equally smooth lava floors and appear to have been formed by lava just as liquid as the bigger maria? Was the moon's crust so thin that the small planetismals penetrated it just as easily as the large ones? Baldwin has postulated a very strong and thick crust for the moon.

According to Baldwin, and I quote: "Both Urey and Kuiper have associated the great lava flows with the collisions which produced the circular maria. Urey found the lava to be from the body of the planetismal. Kuiper specified that the moon was liquid below a thin crust, perhaps 16 km thick, composed of compacted accreted material. Even at a depth of 16 km, the crustal material should have been sintered and compacted. Urey has correctly shown that this thin crust could not be stable over liquid rock of lesser density. Both ideas cannot be right. Either the moon melted or it did not."

It seems quite certain that the moon like the earth and other planets was made by accretion and that the countless hammerings of these infalling bodies, together with the surface magma created by the larger bodies, welded the core of the moon into a solid mass, and with the addition of radio active heat, brought the interior of the moon to a molten temperature, although rigid because of high pressure.

The moon's crust is no doubt quite thick and quite cold, for the lack of air and water insulation would allow crustal heat to escape quite quickly. If this is so, the moon has probably cooled more deeply than the earth with few if any high temperature spots near the surface. This makes it appear that the melted floors of the medium sized craters are the result of impact melting and not from magma coming up from below. If all craters were made "dry," as Baldwin thinks, and the magma came up later, then there is no good reason why they should not have filled to the brim but continued to build into true volcanic peaks. Also, if the moon had contained liquid lava just below a thin crust, then the large craters and maria should have had radiating fault zones and minor volcanic peaks and cinder cones coming up along these collision cracks. Such physical evidence is completely lacking, indicating a strong and thick crust. This does not deny the possibility that the largest maria have been the product of both impact melting and up-welling magma from below.

Another bit of significant evidence catalogued by Baldwin is the distribution of postmare craterlets: "Shoemaker & Hackman have made counts of postmare crater on almost all of the lunar dark areas and find that they are distributed with amazingly similar frequencies. With the possible exception of the dark matter in Mare Crisum, all other areas show the same frequency pattern. The great dark areas, judging from this test, were all formed at essentially the same time. Even Mare Crisium, which shows a light deficit of craters under three miles in diameter, departs from the norm by less than a factor of two."

This frequency pattern of small craters on the maria, is a most important bit of evidence. It probably indicated that all of the maria and many of the large walled plains and smaller craters were made at the same time by a swarm of planetismals or a cometary train. It probably crashed into the moon in a delayed action similar to that described earlier as having struck the earth in the Pacific area. Indeed, it is not impossible that a single large cometary train, caused both events. The truth may be known someday, if men can get enough lava samples from the maria and compare them for age with cores from the deep Pacific Basin.

Whatever the logic or illogic of this latter speculation, the maria on the moon can be reasonably explained as one event. Mare Imbrium's sharper appearance and the fact that its ejecta overlays the surrounding maria, may only mean that it was made seconds or minutes after the others or by a concentration of bodies at the center or rear of the train. This concentration may have heated the lava of Imbrium to a greater degree and scattered it much farther over the moonscape. The fact that the grooves and mountainous ejecta do not line up to *one* radiant point, as Frisoff pointed out, probably indicates a multiplicity of projectiles. Also, those maria like Mare Crisium and Mare Humorum, somewhat away from the others, show separate and individual drift features but all indicate the same direction of approach of the cometary train. This was from SSE to NNW. (See figure Nos. 3, 4, 5)

Baldwin agrees with this direction of approach for Mare Crisium but not for Mare Imbrium or any of the other maria. In fact, he finds a different approach angle for each of the maria. Some, he says, are much older than others, apparantly disagreeing with the Shoemaker-Hackman theory he had cited earlier . . . "Mare Serenitatis is ancient of days. It may well prove to be the oldest of all these vast objects. It certainly was old when Mare Imbrium was born."

In TARGET: EARTH and in more recent short papers we were in agreement with the theory that the maria were of different ages, but the Shoemaker-Hackman postmare crater count changed the picture and we now consider this unassailable evidence that all of the maria are of the same age and made at the same time. This is further borne out by recent photographs of the back side of the moon which shows only one badly battered object of maria size.

We had proposed in TARGET: EARTH that Mare Imbrium was made by several projectiles coming in at a steep angle from the NNW. (See TARGET: EARTH pp, 11) Now it is proposed that the striking bodies came from the exact opposite direction. We had reasoned before, that the high walls of the Apennine and Caucasus and the great volume of debris thrown out on the south side, indicated that the strike came from the north side of the crater. Now we feel that these major impacts produced a blowback of molten material and that the alignment of this material indicates the direction from which the striking object came. (See figure Nos. 3, 4) Another indicator of direction is the direction of crater rim drift.

The heat from all these closely timed and spaced impacts was so great that it produced a huge pool of lava beneath the surface crust. As the heat penetrated toward the surface, great chunks and islands of the mountainous plateau broke off and drifted away from the undercut side (north side) of the crater, thus indicating the direction of approach. This was a true convection cell in which the lava began to circulate, up the crater walls, over, and out toward the

center of the pool. The cell flow was not equal and uniform from all sides because the projectiles were random in size and shape and came in from a high angle from the SSE. This undercut the rim on the north side and caused the whole north rim to drift out nearly a hundred miles, leaving behind the long, narrow maria known as Mare Frigoris and Sinus Roris. (see figure Nos. 4, 5) The long island arc thus produced was pulled in a little on the points as the lava moved toward the center of this huge convection cell. This pulling in of the points caused tension along the outside of the arc and compression on the inside, as evidenced by the widening of the Alpine Valley walls toward the outside of the arc and the pinching in of the horns of Sinus Iridum on the inside of the arc. However, most of the center flow pressures seem to have been relieved by the lava breaking out to the west into Mare Procellarum.

The Carpathian and Apennine rims of Mare Imbrium did not drift because those sides of the crater were not undercut. Never-the-less, a great volume of the Apennine rim slid off into the up-welling lava along that wall and was carried out like floating icebergs toward the center of impact. Much of this debris no doubt melted or sank but a wide band of it remained afloat, extending out some 160 miles from the Apennine wall. (See figure No. 4) Baldwin saw this feature and reports it as follows: "The central area, including the impact crater itself, had absorbed a tremendous amount of momentium, and there had been a great rebound. How long this rebound remained as a structural dome is not certain, but there is definite evidence of its slumping. All along the Apennine front there are great masses which have slid down the scarp and out onto the plain. In the region west of Mt. Huyghens the slumping has carried thousands of cubic miles of rock into Mare Imbrium for 20-30 miles. Much of the material in the highlands near Archimedes and in the Apennine range appears to have been emplaced violently, but whether from the body of the moon or the planetoid, as Urey suggests, cannot be determined." In the above quotation, Baldwin sounds as if he had abandoned his "dry" theory in favor of magma slumping from the impact and he does not make himself clear, whether the thousands of cubic miles of rock slid or drifted for "20-30 miles."

If we hold Baldwin to his theory of dry craters, then the magma coming up from the interior of the moon at some later period, should have come from the deepest or central part of the crater. As it spread out and cooled against the extremely cold rocks of the floor it would tend to build high in the center, sloping down toward the walls. This would have required that the rock debris from the Apennine wall move up-grade the 20-30 miles.* Also, to fill a basin as large as Mare Imbrium under the low temperature conditions that prevail on the moon would require a *superfantastic* amount of heat and rate of flow, otherwise the lava would harden before it could flow the 250 miles to the rim. The "dry" theory would require that the whole basin of Mare Imbrium, at least ten miles deep by Baldwin's own figures, to be filled quickly, so quickly that the whole mass of lava remain liquid hot until the basin filled to its final level. This is an impossible requirement for radio-active heating. It is just as impossible on the earth and the soundest argument that the heat was generated from outside impact. Major collision is the only source of energy known, that can produce the *superfantastic* temperatures in the few seconds of time

*The visible length of the drift path is about 160 miles.

needed to produce these tremendous pools of liquid lava.

Logic forbids belief, but the doctrine of infinite slowness is so entrenched and so fundamental to earth science, that even astronomers insist on transferring it to the moon.

We turn now to the possibility that the crater Archimedes drifted along with the other debris mentioned above. This requires that Archimedes was a young, strong crater of relative light surface material; that it was undercut by the penetration of the meteorites and by the spreading of the lava heat beneath the surface so that it simply floated away with the rest of the Apennine wall toward the center of this huge convection cell. The visible evidence could hardly be more clear. It smoothed a pathway in its wake leaving a row of mountain-sized chunks of rock on either side with a few crowding in behind it. (See figure 4) Then it bumped into the great pile of drift on its southwest side and sticking to this half-molten mass, it came to a stop, turning a little as it did so and causing hundreds of strain ridges to form in the cooling lavas between. The prow side of our fifty mile crater ring is seen to be quite steep, but on either side, a wake of ever-widening waves of lava swing around the rim and come to a point at the stern of our lunar ship. What could be more indicative of drift? Here we have a beautiful example of a true convection cell with lighter, porus material drifting on its surface toward the center. Archimedes was probably a young and deep crater with its bottom well below the surrounding area and any debris that was thrown into it by the explosion would have been melted and absorbed by the lava below. The extra weight of this high rim would cause it to sink into the liquid lava and therefore melt out the bottom, allowing the lava to reach the same level inside the wall as outside. (See figure Nos. 4,)

The crater Plato has had the same origin except that it was probably older and had a lower rim. It drifted along with the whole arcuate structure that broke away from the northern rim of Mare Imbrium. Some ghost rims in Mare Imbrium between Plato and Archimedes may be the result of smaller impact craters made in already molten magma, objects that were in the tail of the train, or they may be other old crater rims similar to Archimedes that moved out too close to the center and were pulled under by the descending currents of the convection cell. The high individual mountain peaks such as Piton which dot this area are perhaps central peaks that failed to sink or drift peaks from the Caucasus.

Mare Vaporum, Mare Aestuum and Sinus Medii (immediately south of the Apennines) were apparently made by meteorites (parts of the comet train) just in advance of the Imbrium group and therefore have been distorted and covered to some extent by material thrown out of Mare Imbrium. To the south and near the center of the moon's disk, the large crater Ptolemaeus appears to have been made by a trailing member of the train and certainly, Mare Nubium, Mare Humorum, Mare Nectaris, Mare Fecundititas and Mare Tranquillitatis, must have been made by the same great cometary train. (See figure Nos. 5, 6, 7) The Shoemaker-Hackman postmare crater count makes this almost a certainty. The fact that some of these maria are not round but have irregular outlines is not important and probably means only that the outpouring lavas flowed into lower surrounding areas.

The true outline of Mare Imbrium (that part which was melted at depth) is difficult to see

on most photographs and one would not notice it unless looking for such drift features. (See figures 4, 5) The whole length of this arcuate structure can be pushed back and stretched a little to fit the irregular shaped rim it pulled away from. The northern edge has a torn-away look just as one might expect and therefore contrasts with the cookie-cut edge on the other side which was made by the several impacting bodies. (See figure 4)

Mare Serenitatis appears to have been made by at least two objects, one more than twice as large as the other. They were timed just right to bulge the Alpine mountains a little way into Mare Imbrium, thus spoiling the perfection of its circular outline. See figure Nos. 5, 7)

Mare Crisium is difficult to see and to photograph clearly because it is so near the eastern limb of the moon. It appears to have been made by one large body, judging by the single large crescent arc that was pulled away from the north rim. It has a north and south diameter of about 220 miles and its east and west diameter is probably about the same but foreshortening along the limb of the moon makes it difficult to measure. (See figure 8) The one large body that struck here threw out a great mass of debris (blow-back) to the south that piled up in a steep mountain rim that is seen sloping away to the south in much the same manner as the material behind the Apennines. Like most of the other maria, Crisium shows evidence that the cometary train came in at a high angle from the SSE. It undercut the north rim and pulled away a beautifully shaped crescent arc of mountains which extend almost half way around the crater rim, tapering to points on the sides. It left an indistinct trough behind this mountain arc that has been somewhat disfigured by later small impacts. The crescent shaped arc seems to be a phenomenon restricted to large impact craters, both on the earth and on the moon, for craters much smaller than Mare Crisium do not show this drift feature, Ptolemaeus, for example, does not. It has a crater diameter of 96 miles; is near the moon's center and can be seen without distortion, yet there is no sign of drift or crescent shaped faulting along its rim. There are a few other "walled plains" even larger, such as Schickard and Grimaldi, but they are so close to the moon's limb that no such small detail can be seen.

Mare Humorum is the smallest maria that shows drift features and crescent faulting. It is roughly 160 by 190 miles in diameter with the longer axis extending north and south. Most of the blow-back is on the south side but with evidence of faulting on both the north and south sides. Several craters along its rim have been swamped by the hot magma from below and have dipped their rims beneath this once molten flood' (See figure 8-A) Baldwin sees this swamping effect but he attributes it to his "dry crater" theory and the long delay of the merging lava. In a personal communication he makes this statement: "This is the critical point. These craters which extend into the impact regions, would have been completely destroyed by the violence of the collision which formed the maria had they been in those positions when the circular maria were formed. I do not think there can be any question of this fact. To take only one example, I cannot conceive of Gassendi being where it was when Mare Humorum was formed; and obviously, Gassendi was not formed after Mare Humorum became filled with solidified lava. There is no mark on the surface of the lava produced by the formation of Gassendi."

Baldwin here re-affirms the statement in his book, "The Measure of the Moon" but he fails

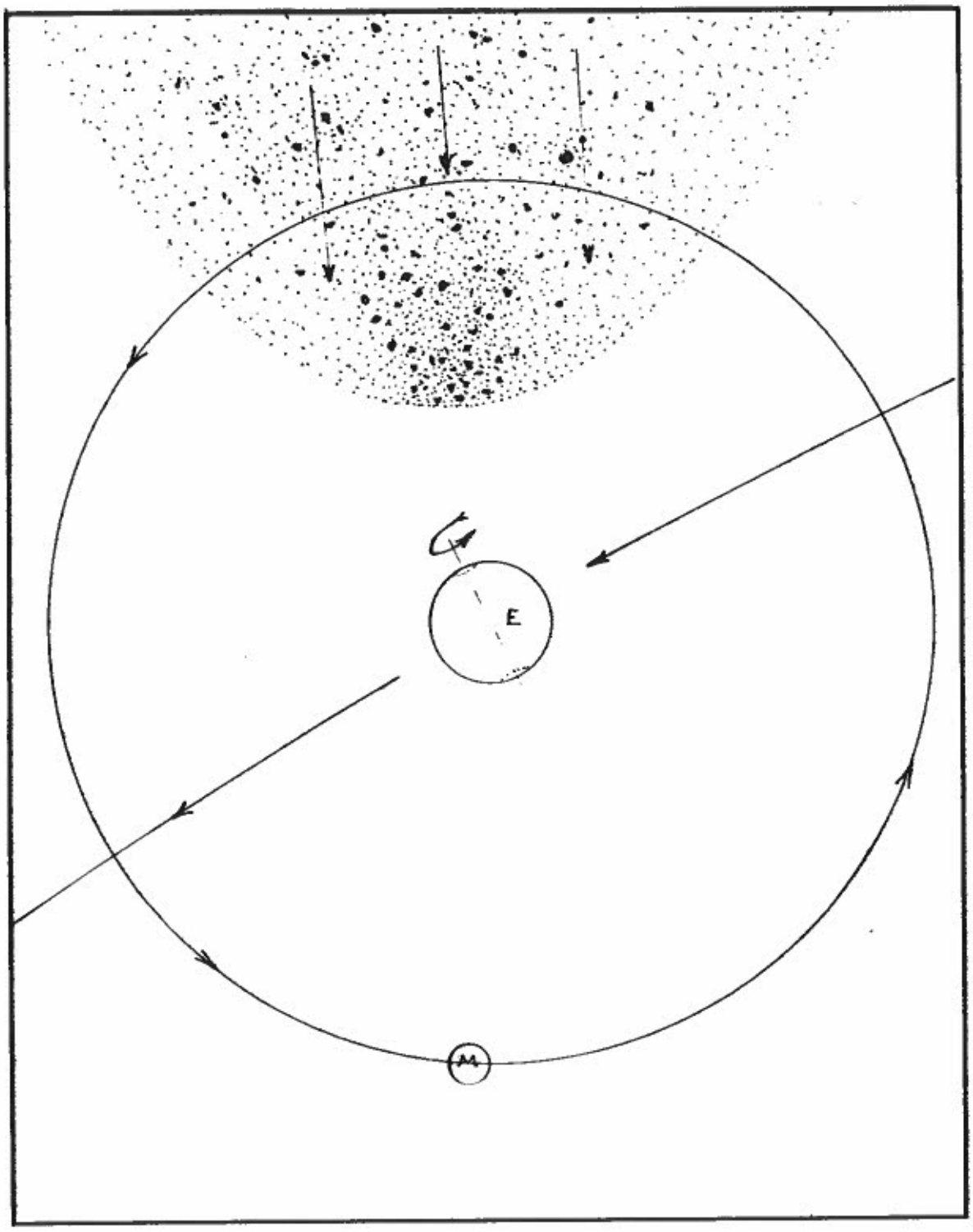


FIG. 2

Illustrating a very remote but possible collision in which a large comet might strike both the earth and the moon so that the maria impact scars always face the earth.

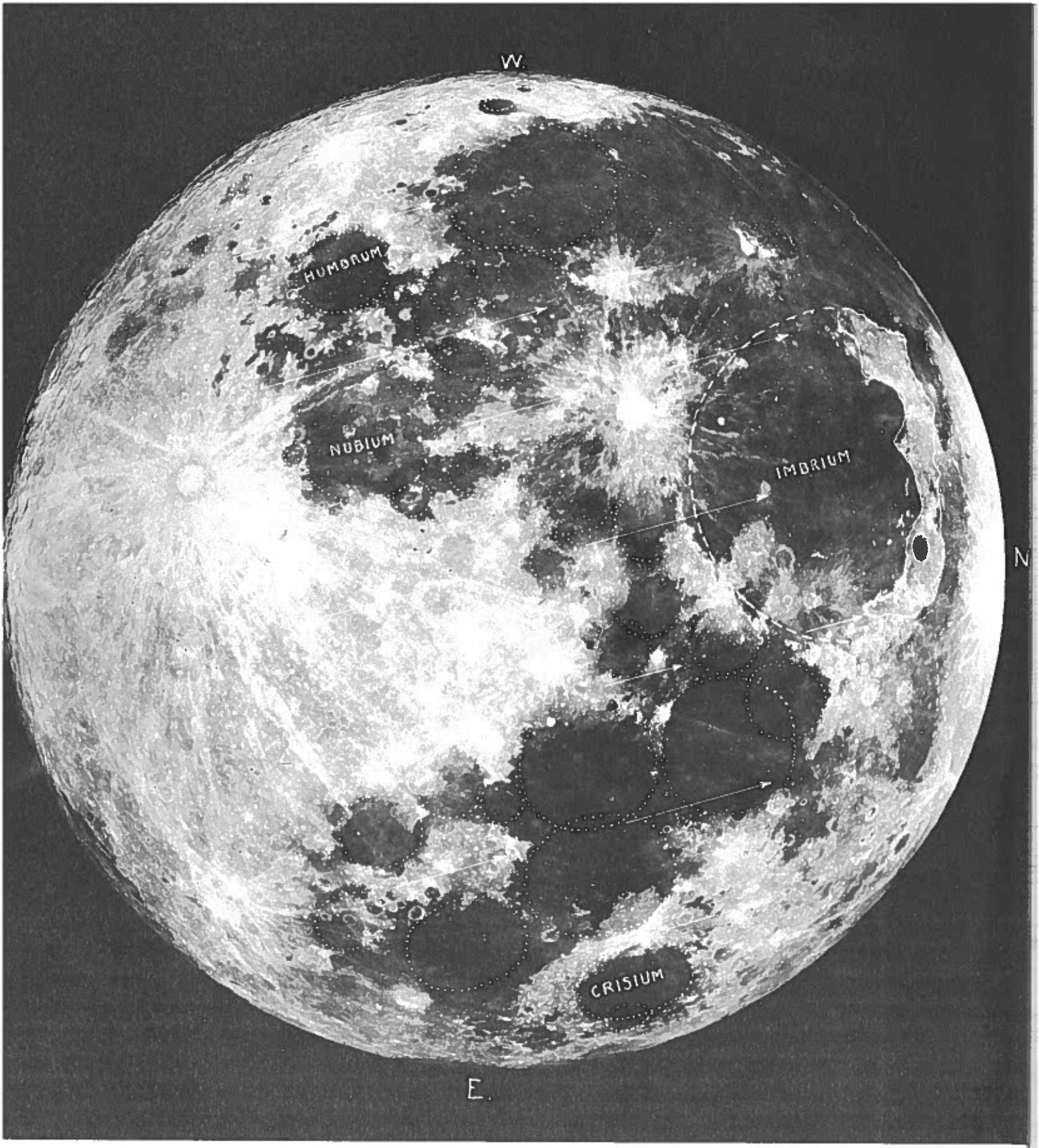


FIG. 3
THE FULL MOON.
Emphasizing the possibility that all of the maria or dark areas are of the same age and probably of the same cometary collision.

FIG. 4
MARE IMBRIUM

Showing supposed multiple impacts and area melted inclosed by dashed line. The arcuate structure marked "drift" appears to have pulled away from the north rim leaving the melted floor of Sinus Roris and Mare Frigoris. Large arrows indicate direction of strike and small arrows direction of drift.

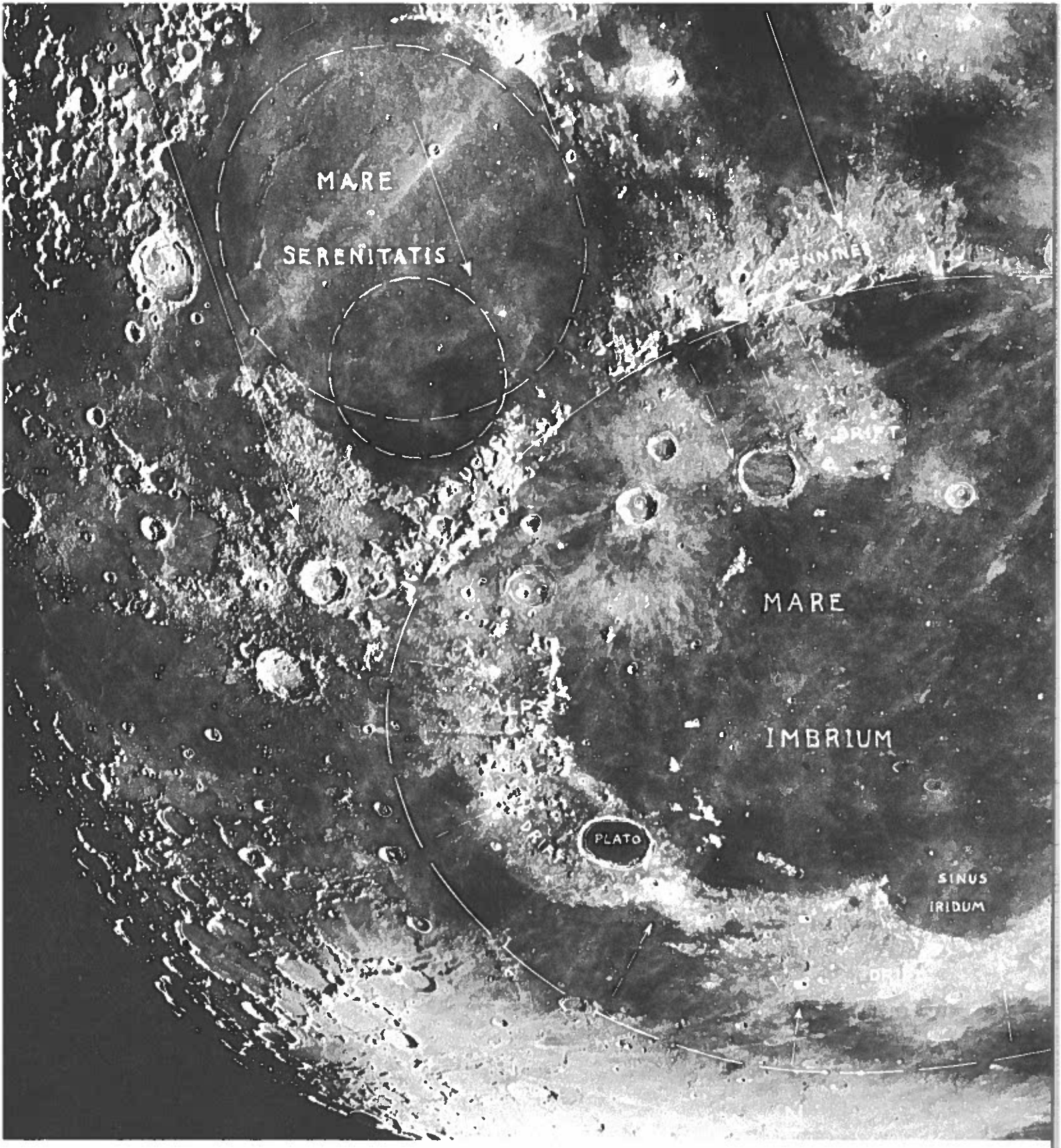


FIG. 5
MARE IMBRIUM and MARE SERENITATIS.
This photo centered near the eastern rim of Mare Imbrium shows the drift features in this section to best advantage.

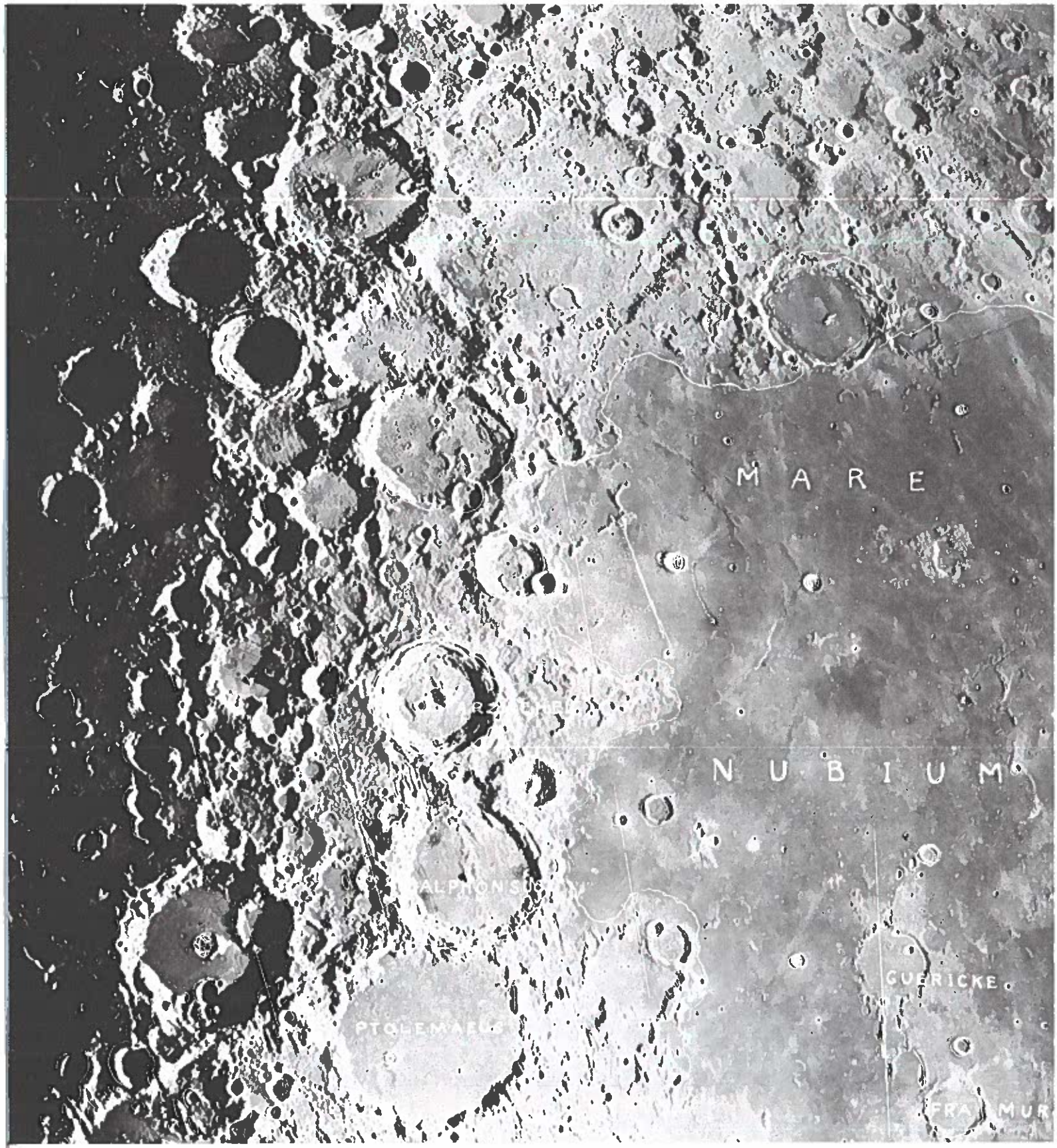


FIG. 6
MARE NUBIUM

Showing splash mountains and grooves made by the Mare Imbrium blast. The large crater Ptolemaeus and the two smaller ones, Fra Mauro and Guericke, appear to have been made by trailing objects in the cometary train for the splash debris does not disturb their surfaces.

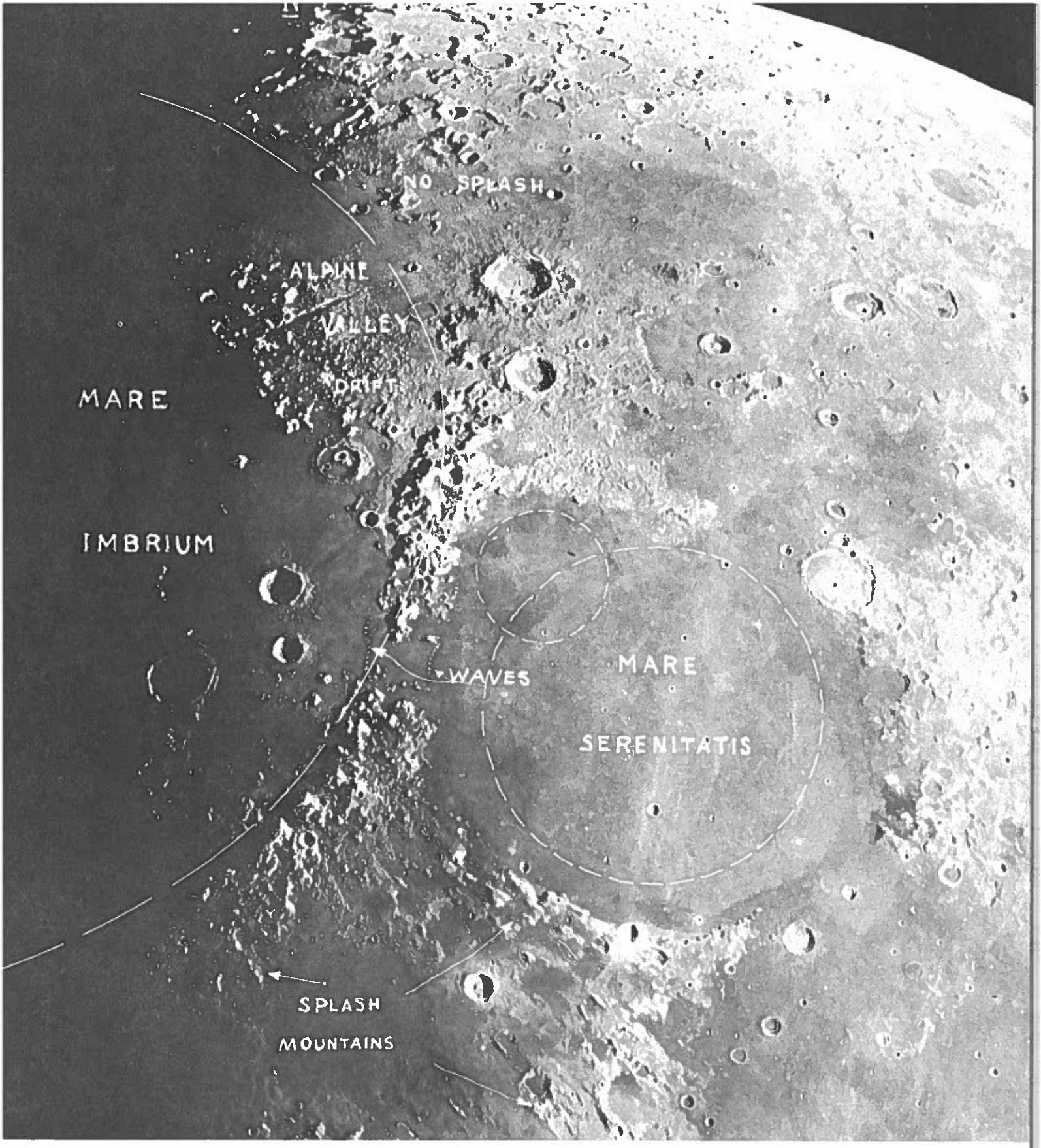


FIG. 7

Calling attention to splash mountains, frozen waves of lava and bulge of Caucasus mountains, all indicating Mare Serenitatis was formed immediately following Mare Imbrium. Alpine Valley is probably not a fault valley but a partial separation of adjoining drift areas.

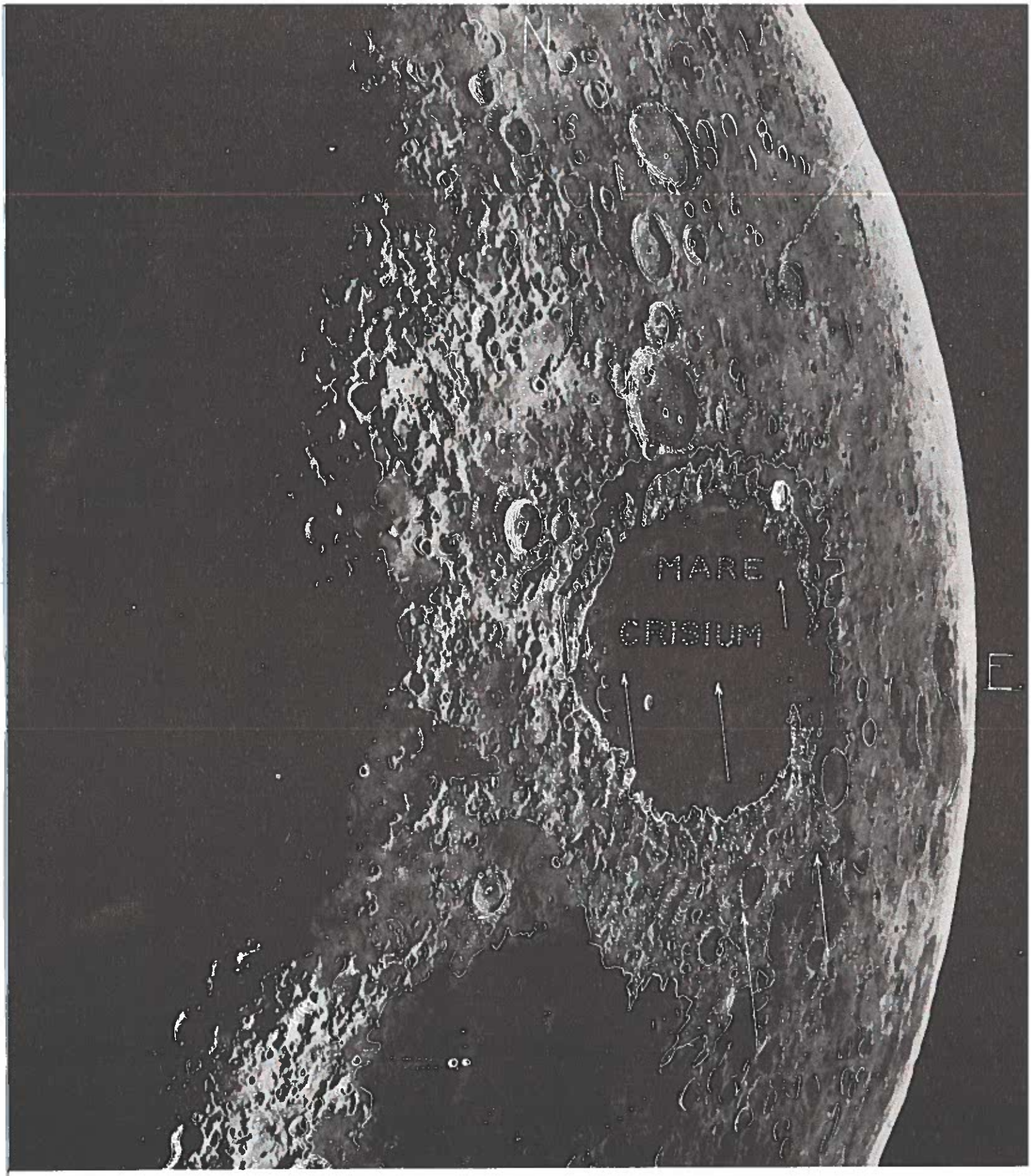


FIG. 8

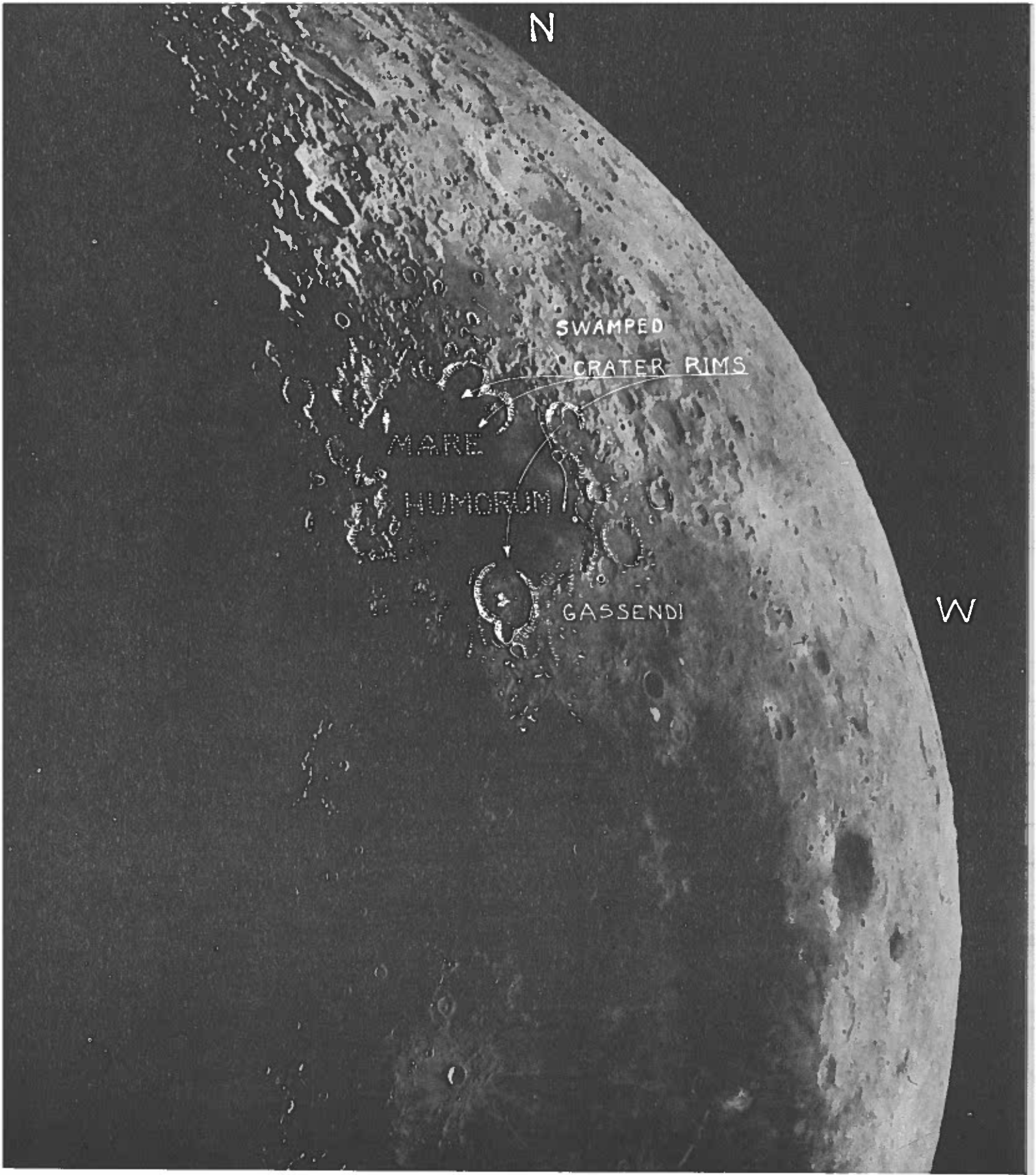


FIG. 8A

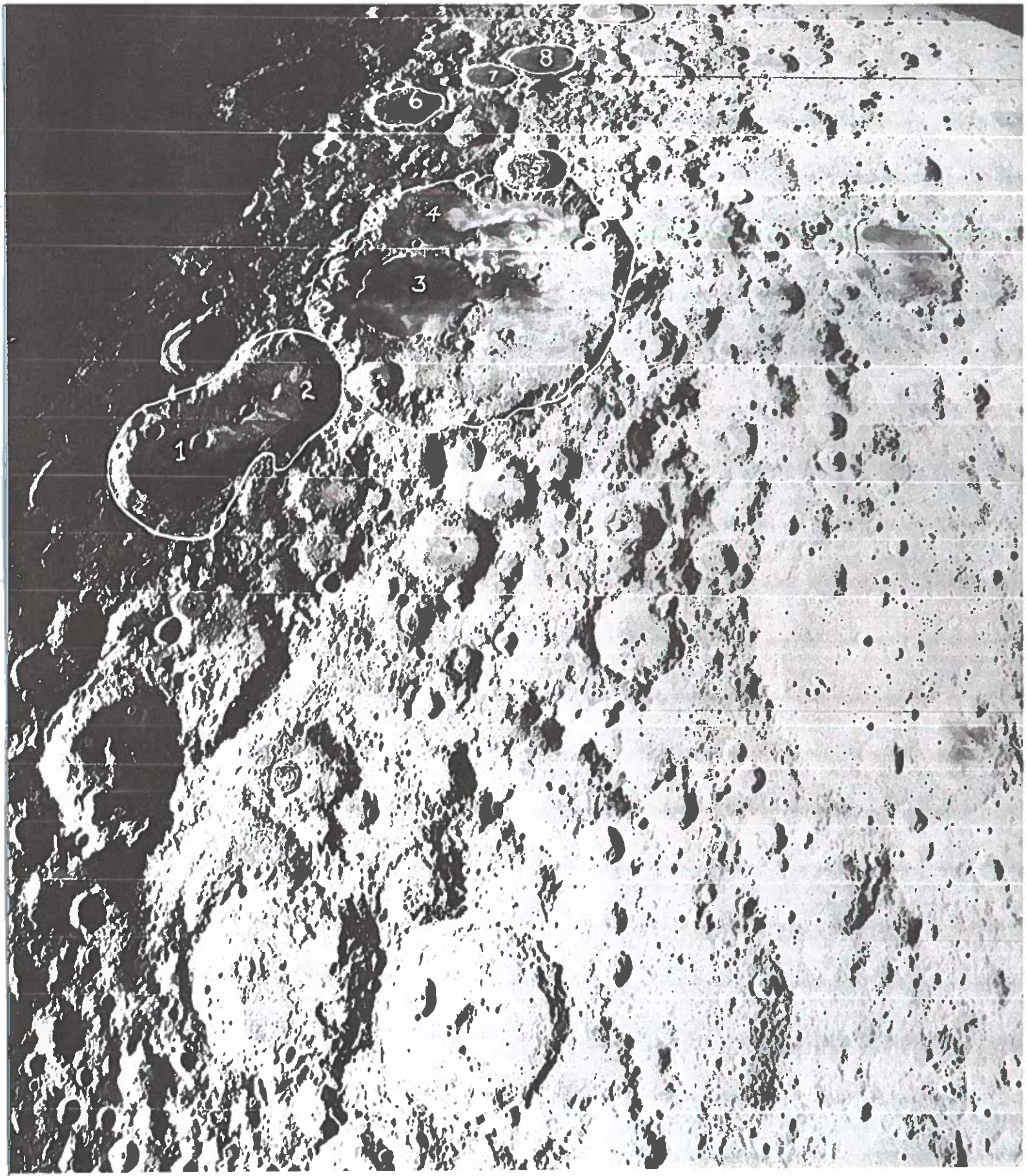


PHOTO NO. 9

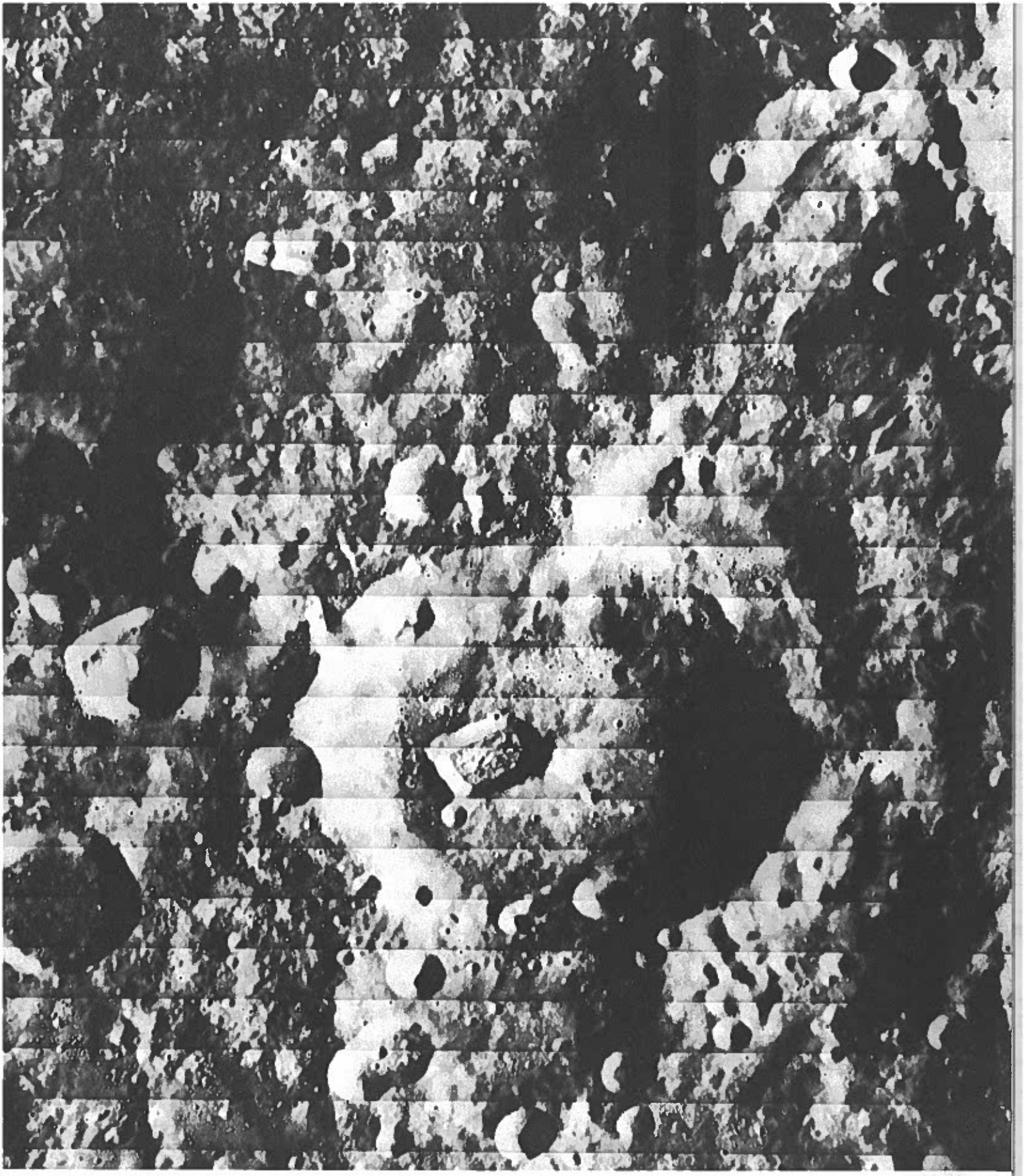


PHOTO NO. 10

THE GULF OF ST. LAWRENCE

The Gulf of St. Lawrence is a circular structure somewhat smaller than Mare Crisium, about 180 miles in diameter at sea level. It has not been accepted as a collision crater but no other less spectacular explanation has been forth-coming. Neither shatter cones or coesite has been reported nor do we have any knowledge of whether a systematic search has been made for these collision indicators. There is little sign of a crater rim except in the Cape Breton Island sector where steep bluffs rise to about 1000 feet. This huge basin is located in granitic rocks and gravametric surveys across this basin in two directions have enabled Canadian scientists to determine a depth to basement rock (near Prince Edward Island) of 22,000 feet or a little more than four miles. This great depth of sediments is very unusual because the greater part of it seems to be rock salt. In talking with Dr. McNeil, a long-time geologist with the Shell Oil Company and now Professor of Geology at St. Francis Xavier University at Antigonish, Nova Scotia, we learned that the Shell Oil Company drilled four wells in the Gulf of St. Lawrence basin; three of them on Prince Edward Island and one near Inverness on Cape Breton Island. Of the first three, one stopped at 920 feet in granite, the second, on the north end of the island, went through several thousand feet of alternating beds of sedimentary and volcanic rocks and the third, drilled on a small island in the bay near Charlottetown, went to 17,800 feet. The first 9000 feet of this well was in sedimentary rocks and then it went into rock salt and continued in that material until abandoned at 17,800 feet. The fourth well near Inverness, struck rock salt at 910 feet and continued in that material until abandoned at 5000 feet. If all of this basin is underlaid with rock salt we have need of cataclysmic explanation. It cannot be explained away as merely the ordinary slow process of sea water evaporation continuing over hundreds of millions of years. This would require the slow, uninterrupted accumulation of salt just equaling the slow sinking of the basin, through whole eons and epochs of time; times in which great "revolutions" in the earth's crust were taking place close by in the Appalachian mountains. It is probably significant, that most of these great deposits of rock salt, both in North American and in Europe, Persia and North Africa, are found to be of Permian age, the time when the greatest of all cataclysms took place. These tremendous beds of pure rock salt, often crystal clear, bring questions to mind: can such thick beds of rock salt be of collision origin wherein huge quantities of sea water flowed into a crater basin on top of molten magma? Was the water flashed off, leaving the salts in a molten condition that continued to flash off additional sea water as it entered the basin, thus building up the great depth? How pure is this rock salt and is there any interbedding of marine or land sediments? These are questions that need a great deal more investigation.

Somewhere we have read (reference lost) that the granite coasts of Newfoundland and Nova Scotia match those of Europe including England and that the Pyrenees are probably the extension of the mountains of New England before continental drift took place. If this were the case, then the Gulf of St. Lawrence, like the crater Plato, may have drifted from its Mid Atlantic Ridge position to its present location.

Large scale maps of the Atlantic Provinces show many channels and bays that appear to have originated as cracks or faults in the earth that have opened up or widened at one end. The mouth of the St. Lawrence River gives this impression, being an ever-widening arm of the ocean that extends NE from the city of Quebec for nearly 300 miles. The next large crack that seems to have opened is Chaleur Bay, just south of the Gaspe Penninsula. This one is followed by a number of smaller wedge-shaped bays and then the Bay of Fundy, which opens away from the arc. (See figure No. 9) This huge inlet appears to have opened up, and even though scoured by glacial ice and littered with glacial debris, the sides still match quite closely and invite the observant geographer to push them together again. The elongated bays, and the parallel faulting of the granites of Cape Breton Island Nova Scotia and Newfoundland, all speak of deep crustal faulting and the possibility of continental drifting. (See figure No. 9)

Prince Edward Island gives strong evidence of being an arc of collision origin similar to the crescent arc of Mare Crisium. Close investigation might prove that four or five spearate chunks of crater rim have been crowded together here and could be fit back into notches in the adjoining rim. (See figure No. 9)

The Magdalen Islands may be a product of collision-drift too. Their slender curving shape and their somewhat off-center location in the Gulf of St. Lawrence, make them quite unique in the world except for the Belcher Islands in the Hudson Bay Arc, which are very similar. We have been unable to learn what rock formations are to be found on the Magdalen Islands, whether lava, granite, sedimentary or metamorphic, but if they are of collision-drift origin they should fit back on some section of the crater rim from which they have drifted.

Prince Edward Island is low and made up of nearly flat-lying sedimentary rocks and interbedded shales, with an overburden of glacial till 20 to 50 feet thick. Scattered through much of this till one may see light colored granite boulders that appear to have been transported from the southeastern coast of Nova Scotia, for that was the only area around the Gulf of St. Lawrence where we saw rocks of similar kind in place. The drift, which covers most of Prince Edward Island and the surrounding shore, was apparently set down in place by the melting ice because the weak rocks and shales of the island could not have withstood the movement of thick glacial ice. The channel between the mainland and the island is very angular in outline and shows no sign of directional glaciation as would be the case if ice had moved through this channel. The other side of the island is a smoothly curving arc that looks as if it could have been the edge of the original crater rim, or sections of it that were pushed together as drifting took place. Only the northwest tip is turned a little out of line. There is a possibility too, that the southern tip of Prince Edward Island has an underwater extension along the curve of the shoreline but off-shoe about ten miles. An old sea captain who runs a motel at Chiticamp on the N.W. coast of Cape Breton Island told me of an underwater ridge paralleling the coast for many miles that forms a "fishing bank" from which most of the local catch is made each year.

Much of the above will be criticised as pure speculation by those who profess to arrive at geological truths without speculation. However, we believe that it has some merit and, in contrast to some speculations about what goes on inside the earth's mantle (convection currents

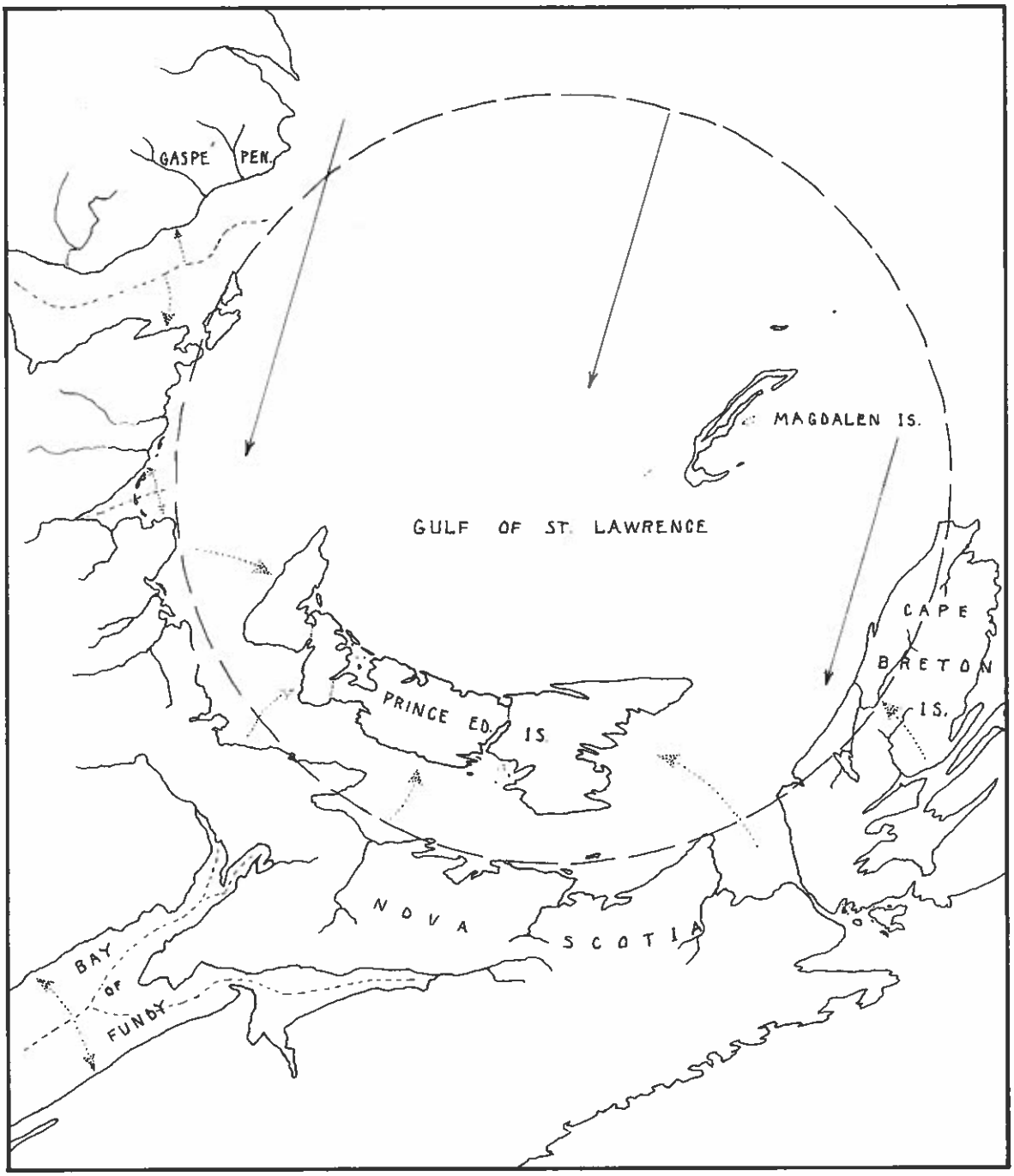


FIG. 9

The Gulf of St. Lawrence arcuate structure. Dotted arrows show supposed direction of drift. Solid arrows, direction of approach of striking body.

etc.) these physical features can be verified by those who will take the trouble to go there and see for themselves.

THE VREDEFORT RING

Another very ancient basin structure which may be of collision origin, is the Witwatersrand Basin and Vredefort Ring located in the northeast corner of SOUTH AFRICA. The rim of this basin is the greatest gold-producing area of the world and also, one of the greatest geological mysteries in the world. Its origin is shrouded in the mists of Pre-Cambrian time, for this is indeed, a very ancient structure. Mountains have risen to the skies, given their rivers of water and their flakes of gold to the sea and vanished. But the roots of these mountains remain and men search there for gold and for the answers to these ancient mysteries. For man has ever wondered why!

WHY?

Deep in an Eocenic Sea
The Zeuglodon's an absentee;
The Trilobite by trillions quit,
Perhaps because he didn't fit,

Tyranosaurus cooked his goose
For reasons that appear abstruse;
The Pterodactyl ceased to fly
And man has ever wondered why.

With apologies to David McCord

The city of Johannesburg is situated on the north rim of the Witwatersrand Basin among low parallel ridges that rise some 200 feet above the surrounding plains. The shape of this somewhat deformed basin is outlined by the gold mine dumps that line this rim as far as the eye can see. The basin rim as a whole, is somewhat tipped to the southeast so that only about 170 degrees of the arc are seen as the tilted beds of metamorphic rocks that rise above the younger glacial sediments forming the surrounding plain. (See figure No. 10)

This great basin is about 200 miles across and one may best see its curvature from a high flying airliner coming into Johannesburg, for the circle is so large it is difficult to see its curvature from the ground. A better close-up view may be had from the 550 foot concrete observation tower that is built on a hill-top near the center of the city. From this vantage point, a line of yellowish colored mining dumps may be seen stretching away in either direction, east and west. This line of mining dumps is seldom more than a mile wide and follows the rim of the steeply dipping metamorphic rocks which are only exposed in scattered sections along the cir-

cle. (See figure No. 10) The other 190 degrees of the circle are hidden under the ancient glacial drift known as the Karroo System, so that the existence of the rim, while inferred, is not certainly known. (See figure Nos. 10, 11)

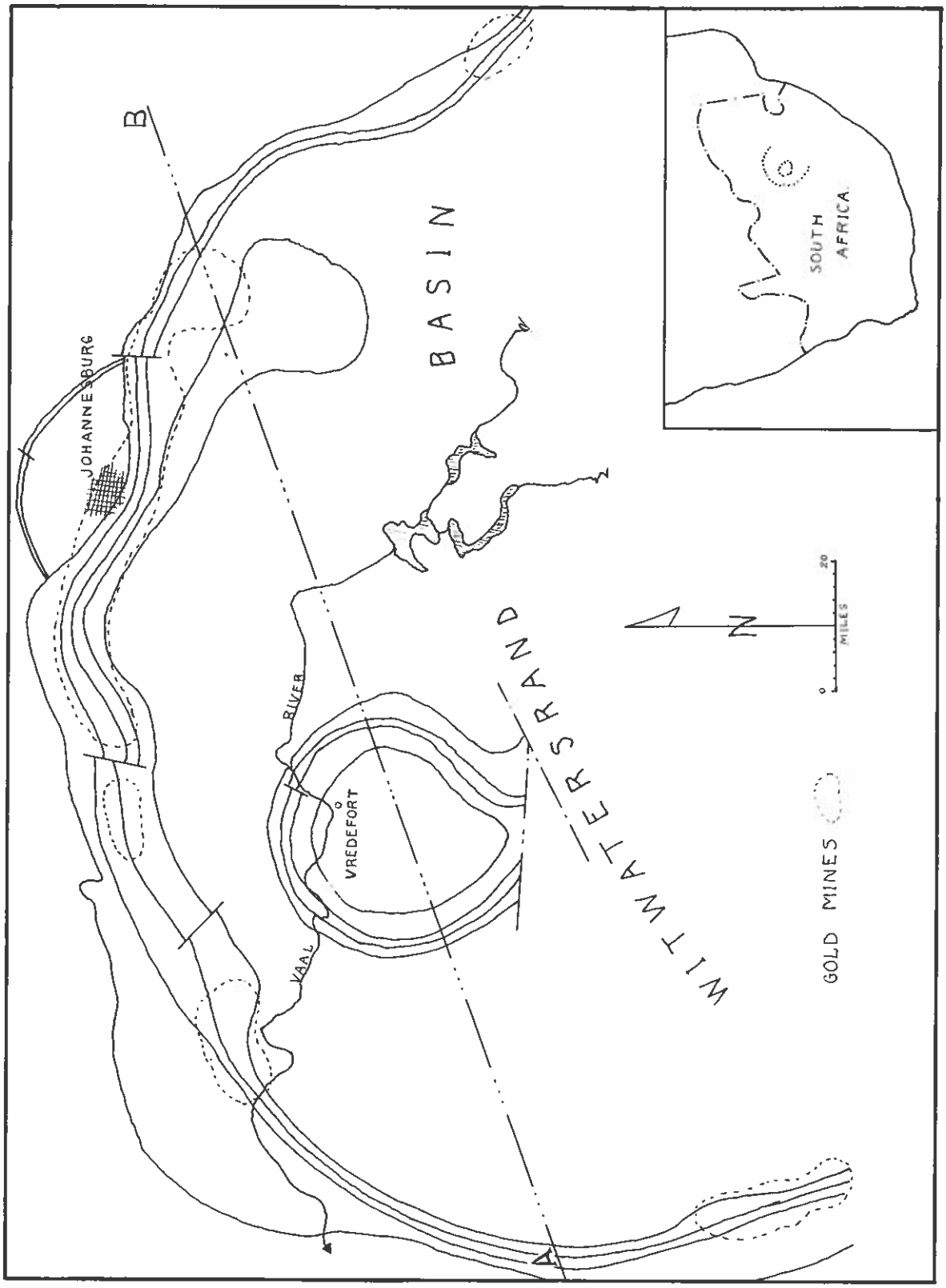
A secondary feature of this structure is the huge granite plug that is located a little off-center. This granite plug is about 25 miles in diameter and surrounded by rings of old sedimentary and metamorphic rocks that come to the surface at a very steep angle. In some sections they are even overturned toward the rim of the basin. They are the same strata and lie in the same order as those in the rim of the basin, and being more weather resistant than the granite, stand above the granite plain. It is in these highly shattered rocks around the granite core, that "Shatter cones" have been found. (See ASTROBLEMES by Dr. Robt. S. Dietz, SCIENTIFIC AMERICAN, August 1961)

Dr. Dietz was first to see the significance of "shatter cones" and to prove that they had their origin in high velocity shock waves caused by massive meteorite impact. Shatter cones are now considered along with coesite and stishovite (high pressure forms of quartz) to be the best indicators of fossil meteorite craters.

The writer had occasion while in Johannesburg to talk with a Mr. Carlson, a geologist and mining engineer with the South African Institute of Mining and Metallurgy. He explained the Witwatersrand Basin and the Vredefort Ring from his geological viewpoint and drew a cross-section through the ring and basin to show what has been found in their deep mining operations. (See figure No. 11) Mr. Carlson and other geologists active in this area, while having heard of the shatter cone discovery, are not much impressed. They feel quite certain that this basin is not of collision origin because the thick sedimentary rocks follow down the curve of the basin and up the sides of the granite plug. From this fact they reason that the Witwatersrand Basin was made by subsidence; that this once level series of sediments settled down with the basement rocks. (Why the basement rocks settled is not known) Later, they believe, the granite plug intruded these sedimentary rocks and slowly uplifted and overturned them to form a central mountain peak. And finally this peak and once higher basin rim, were eroded down to produce the level sediments that now fill the basin surrounding the granite plug. They further argue, that impact could not have occurred in the level sediments without destroying them so the impact basin, if it is one, must have been made before the sediments were laid down. That sediments cannot be laid down in layers following the slope and therefore there was no impact.

Some of this is good reasoning but it does not prove that a basin 200 miles in diameter can subside into the dense basement rocks of the earth's crust where pressures are extreme and voids are unknown. There must be a better explanation.

Dr. Dietz in his article (ASTROBLEMES) takes a different view. He bases his explanation of the Vredefort Ring on a colliding body one mile in diameter. "The huge object drilled into the earth and released enormous shock forces, causing a gigantic upheaval. Strata nine miles thick peeled back like the petals of a flower spreading before the sun, opening a crater 30 miles in diameter and ten miles deep."


B
BASIN
JOHANNESBURG
VREDEFORT
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SOUTH AFRICA

FIG. 10

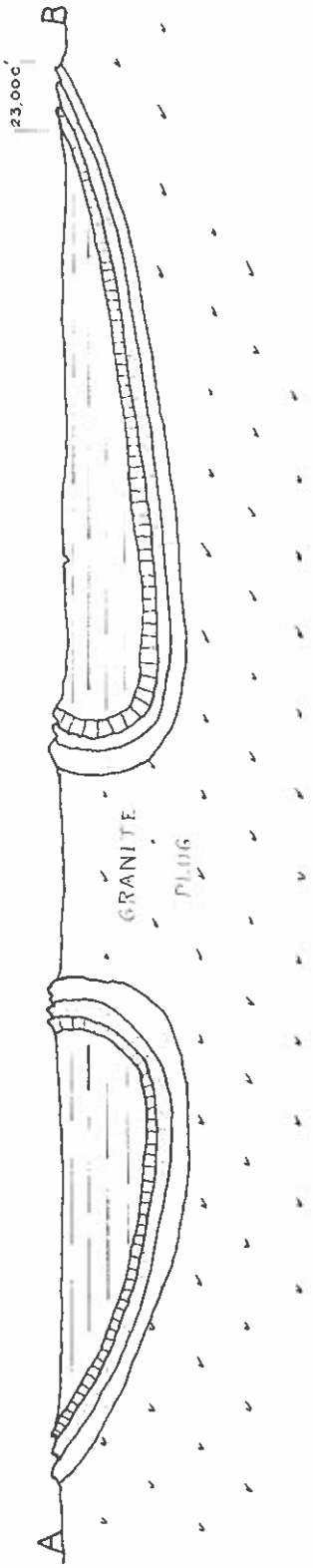


FIG. 11

Cross section through Witwatersrand Basin from A to B.

Dr. Dietz says nothing about the great outer ring and basin, but apparently takes for granted that the area was covered with sedimentary rocks, presumably level; that the meteorite blasted a 30 mile hole through this strata into the granite below; that the viscous rock formed by the impact pushed up to fill the hole and lastly, that the plug and rim rocks were worn down by erosion to their present form to fill in the basin around the plug with the level sediments. This fails to explain the whole structure and how the shatter cones got into the up-turned rocks around the plug.

If we might offer a more elaborate speculation: First, a major collision in Cambrian or Precambrian time produced the 200 mile crater basin. This striking body produced a pool of lava that probably filled the crater to within about 20,000 feet of the rim. If the rim was near sea level, ocean water may have rushed in producing deep beds of rock salt. This primary collision was followed by a time lapse of millions of years in which ordinary erosion and an occasional collision-coeanic-flood, served to fill the basin to the rim. Then came a second collision which produced the shatter cones in the deep sedimentary rocks on the floor of the old crater. This object struck the old crater basin a little off-center and formed a new crater 25 to 30 miles in diameter. Following this, another long period of time was brought to a close in the great collision ending Permian Time. This was the great cometary collision that formed the Pacific Basin and shook the earth to its very core and moved the axis to a new and far-distant location. As the continents began to drift and as the African Rift opened, this old crater basin, being near the rift and a weak spot in the earth's crust, the old crater floor began to sag as the magma beneath moved away toward the rift opening where the pressures would have been reduced as the magma found new space to occupy. Then this portion of the rift began to close again and the direction of pressure was reversed so that a column of magma was forced back up through the 30 mile in diameter crater to form the granite plug. As it came up, it pushed the surrounding metamorphic rocks with it, bringing these deeply buried rocks and their shatter cone inclusions to the surface, even overturning them a bit toward the Witwatersrand Rim. The magma turned to granite because it cooled very slowly under a deep overburden of broken metamorphic rocks that must have formed quite a high mountain peak. This peak and the outer rim were then worn down to fill the basin with the new series of level beds. Most of the erosion was due to the melting of the pre-collision Permian ice cap that had covered nearly all of southern Africa and to gigantic oceanic flooding caused by the cometary collision. In flying over this great African plateau one is impressed by the near-level surface of the land and the widespread evidence of glaciation. Farther south at Capetown and in the mountain ranges that parallel the southern coast of Africa, there is no sign of this Permian glaciation.

No discussion of the Witwatersrand Basin would be complete without some mention of the gold found there and its origin, for this is the greatest gold-producing area in the world. There are 62 gold mines and nine uranium mines along the rim of this basin from which, more than a billion dollars worth of precious metal is taken each year. Because of the steep dip of the formation and the gold-bearing reefs, only the rim of the basin can be mined profitably and most of the mines on the rim are working at depths below 10,000 feet and one is said to be nearing

13,000 feet below the ground surface. The interesting thing about this gold is that it occurs as "placer gold" rather than as a volcanic intrusive into quartz veins as is often the case. The rim itself, often called the "Rand"* is a thick series of tilted sedimentary rocks that measure some 23,000 feet across the surface of the ground at Johannesburg. The gold is found in four separate layers or "reefs" which are in turn, separated from each other by thousands of feet of intervening beds of barren strata. The geological mystery here is to explain how (in orthodox terms) the mountains around this basin suddenly began to produce "placer gold" carrying it down to the lake or sea-filled basin where it was widely distributed in a single thin bed. Then as suddenly, the deposition of tiny specks of gold ceased and additional hundreds or thousands of feet of new sediments were laid down before the next "reef" suddenly began. These "reefs" are very thin, varying from only a few inches to about four feet in thickness. All this is quite un-natural if we try to explain it by ordinary stream erosion and sedimentation. For example, if we conjure up mountains around this ancient basin containing gold and uranium then we must suppose that all of the streams, at the same time, started to carry gold down into the basin and then all at once, they stopped. Mountains are not this uniform in their content nor streams in their size or carrying capacity.

The only possible explanation seems to be that the tiny specks of gold were rained down like volcanic ash. That they fell in ocean or lake basin along with the matrix material that rained down at the same time. Gold is much too heavy (specific gravity 19.3) to be carried long distances and especially out into a lake or ocean basin where transportation would depend on currents less than one mile per hour.

All this points to an extra-terrestrial origin for gold or other heavy metals when found in wide-spread beds of sedimentary rocks.

Since the earth is thought to have grown by accretion, the heavy metals must have arrived in this way too, and we know that meteoritic iron reaches the earth in this manner. We reason then, that when a large object struck the earth, vaporization took place, spreading a cloud of gas over thousands of square miles. When the elements in this cloud condensed, according to their different temperature ranges, they rained down as a fine grained dust or sand. If gold, uranium, or other heavy metal was contained in the comet or meteorite or in that part of the earth's crust that was vaporized too, then it was rained down and deposited in a separate and distinct bed in a short period of time. This explains the wide-spread deposition of the gold in thin beds and its sudden beginning and ending. (See TARGET: EARTH, Kelly & Dachille, Genesis of Minerals)

Other heavy metal deposits of an unusual nature have recently been attributed to meteoritic impact. One in particular, the Sudbury Structure in Ontario, Canada, seems to be a deformed crater basin in which the heavy metals have been driven into the walls by explosion.

Dr. Robert Dietz found shatter cones in the walls of this crater structure just outside the zone where the rich deposits of nickel, copper and silver are found. Mining operations carried on for years at this site have proven that practically all of the metal is in a thin shell in the

*The "Rand" is the South African unit of exchange worth $1.40.

shattered walls of the crater and in fissures that radiate into the country rock. The interior of the basin, now deformed by lateral pressures from later events, is filled with sedimentary rocks quite barren of metal. This points to the possibility that some of the material circulating in the solar system must contain concentrations of the heavy metals and that this means that they must have had their origin in the interior of some disrupted planet. If the asteroids are the remains of a disrupted planet that occupied the space between Mars and Jupiter, then we have a logical source for the origin of the heavy metals, and the mechanism by which they were concentrated in certain areas. There is no really good evidence that the heavy metals came from the interior of the earth, that they were extruded into the crust from below. All of the evidence used to substantiate convection currents is derived from surface features that can be explained as well or better by collision and collision is a *fact*, not a theory.

We know too, that the deep interior of the earth is very hot and very dense; that heat can rise against gravity and in opposition to the law of conservation of angular momentium, while the heavy metals and magmas must obey these laws. That the extreme constancy of the earth's rotational and orbital speeds argues strongly for the near perfection of its heat-equilibrium deep within the mantle where convection currents are supposed to start. In short, that *all* known earth forces tend to produce a greater and greater degree of mass equilibrium. Only those wanderers from space which collide with the earth upon rare occasions, can upset the perfection of this finely balanced timepiece.

THE HUDSON BAY ARC

The Hudson Bay Arc is a striking feature on any map of North America because of its size and because of its near-perfect half circular outline in a region of angular coast lines. However, the really unique and unusual features of this area are not seen until one studies a large scale map of the islands, rivers, and coast lines in detail. Until quite recently, no good detail maps of this area were available. It is still a wild and nearly uninhabited region, difficult to reach except by air, and with a climate such that air travel is limited to a few weeks in the summer when the ice is melted from the rivers and from the waters of Hudson Bay. Because of its inaccessibility, little geophysical work had been done there except for the exploration of a few mining companies. Now the picture is changed. With the advent of aerial photography, the whole of Canada has been surveyed and mapped, much of it on a scale of 8 miles to the inch.

About the time that aerial photographs became available, a new interest in meteoritics took place and Canadian scientists began a systematic search of their aerial photos for meteorite craters. This proved very rewarding for many new crater structures were found. One of these, the Hudson Bay Arc, had long been suspect as an impact crater. (See TARGET: EARTH, Kelly & Dachille, pp 58) Its great size and inaccessibility have made careful investigation difficult, and while it has not been formally recognized as an impact scar, most investigators lean in that direction for there is no other logical explantion of its origin.

The Hudson Bay Arc measures 276 miles from point to point across its visible section and 372 miles along the periphery of the arc. Since the visible part of the arc is not a full 180 degrees, a projection of the curve produces a full diameter of 288 miles and a circumference of 905 miles. This presumes that there is some underwater evidence of the crater rim on the west side but it may be that no such rim exists. It may be that the depression of Hudson Bay was already in existence when the collision took place so that the lava generated merely flowed out into that area much like the overflow of some of the large maria on the moon. (See figure No. 7)

There are several good reasons to lead one to believe that this great arc is of major collision origin: First, the long chain of islands that parallel the arc are unique. Nowhere else in the world do we find such a structure. This uniqueness is emphasized by the myriads of islands scattered at random along the adjacent coasts to the north and south of the arc. Obviously, these were made by ice moving down-grade into the water. In contrast, the ice seems to have moved away from the water and up-grade all along the central part of the arc where the rivers now run down into the sea in the opposite direction. How was this possible? And how could ice moving either in or out of Hudson Bay, leave the paralleling chain of islands, a rim along the mainland shore and a deep channel between?

There can be no doubt that the whole area of Hudson Bay and the Canadian Shield was covered with a thick blanket of continental ice in Pleistocene time. It is plain to see that strong glaciation took place. The question is when? And the second question is how?

First, we must think the problem through from the orthodox geological viewpoint: How could ice erosion or water erosion and sedimentation or any combination of these forces along

with volcanics or diastrophic forces have produced the physical features we see along this arc and the islands within its circumference? We confess a complete inability to explain these features in an orthodox manner and the only answer we have had from the orthodox geologist is that the Hudson Bay structure is so old, so large and so inaccessible that the problem is well-nigh beyond solution. Despite this attitude there is a great deal of interest in the problem and the Canadian scientists are giving it a hard try. Indeed, the solution of this problem, the final admission that major collision is the answer, may be the final blow, the death knell of the theory of Uniformity.

It is becoming increasingly clear to the formally trained geologist that acceptance of a scar of this magnitude as a geological fact is going to mean a complete re-organization and re-writing of our geology text books; that the origin of mountains and ocean basins, the theories of sedimentation, erosion, vulcanism, earthquakes and many other lesser pheonomena are going to need revision.

At a meeting on Meteoritics held at Penn State University in October of 1963, Dr. Alvin Cohen of the University of Pittsburg, gave a talk on the Nastapoka Islands and illustrated his talk with color slides. He had flown over these islands in August of that year with Dr. C. S. Beals, Director of the Department of Mines and Technical Surveys, Dominion Observatory, Ottawa, Canada. The writer's personal observations concerning the Nastapoka Islands and other features of the Hudson Bay Arc are based upon Dr. Cohen's talk and color slides and upon Canadian Goverment aerial photographs and large scale topographical maps together with personal communications, bulletins and other written material received from time to time.

According to Dr. Cohen, the rocks in the Nastapoka Islands are banded gneisses capped with lava, and with a few exceptions, all are tipped toward the center of Hudson Bay. This was quite apparent in the pictures which were taken from a low altitude and showed these features quite plainly, especially the lava caps, which appeared to be columnar basalt in beds from 20 to 50 feet thick. The gently sloping tops are bare rock with little or no sign of loose glacial drift. The light colored bands in the gneiss could be clearly seen in the near-vertical cliffs that form the shoreward sides of these islands.

Another interesting feature seen in the color slides was the narrow band of green water at the foot of the cliffs and its sudden darkening into the deep blue color of the Nastapoka Sound. If this channel between the islands and the mainland is as deep as it appears and especially, if it is found to be deeper than the water on the western side of the islands, it will be very strong evidence of a tensional trough such as found outside the Pacific island arcs, a feature we have long cited as major collision evidence. (See TARGET: EARTH, pp 99-101)

A further mystery of this arc and the surrounding glaciated area is what happened to the glacial debris? The aerial photographs show that thousands of square miles of this Canadian Shield are bare, glaciated rock. It is near level to gently rolling with the depressions filled with lakes nearly equaling in area the bare rock, yet only minor deposits of loose glacial rock are to be found. What became of all this glacial debris? Was it carried far away to the plains of Canada or into the Atlantic Ocean? How is it that the ice moved outward and up-grade from

this particular section of the Hudson Bay Arc while the rivers underneath the ice moved in the opposite direction into the Nastapoka Channel? And why was this channel not filled with glacial mud and gravels if the ice melted from uniformitarian causes? What about the five advances and retreats of this ice during the glacial stages of the Pleistocene? Can the orthodox glaciologist explain this lack of glacial debris and other anomalies?

And consider the Belcher Islands: They cover some 3600 square miles in Hudson Bay and lie a little southeast of the center described by the arc. (See figure No. 14) They consist of long, narrow ridges lying in loops and curves, with some flat areas covered with small lakes. The ridges and most of the flat area average about 200 feet above sea level. (See ATLAS of LANDFORMS, U.S. Military Academy, West Point, page 36) The sea around these islands is quite uniform in depth, about 50 fathoms and these narrow, looping ridges rise above that floor 300 to 500 feet. How could continental ice have moved in any direction without cutting these loops to ribbons, yet the photographs show that these islands have been strongly glaciated. The only logical answer to this set of facts and features would seem to be a sequence of events as follows: First, the whole area of the Canadian Shield was glaciated to a near-peneplane, much as it is today. This must have occurred previous to Permian time. The Precambrian granitic gneisses of the Shield, then covered by thick continental ice, was struck by an object coming in at a high angle from a little south of east. It blasted off the ice in all directions but more strongly toward the ESE, the direction of blow-back. A gigantic convection cell of molten rock was produced with more heat and undercutting generated on the western side, so that long strings of the western crater rim were broken off and drifted toward the off-center (coolest part) of the convection cell. Thus was formed the spaghetti-like mass of the Belcher Islands, already glaciated to the same level but now mixed until the surface grooves run in all directions. This area having been in an arctic region, the ice reformed again in a slow gentle manner that produced another ice cap probably more than a mile in thickness. This ice remained in place and never melted until the end of the Pleistocene.

The chain of islands along the arc including the Hopewell Islands, the Nastapoka Islands, Castle Island, Merry Island and Long Island were all made at the same time but since there was less heat generated under the eastern side of the arc (because of the angle of approach and therefore no undercutting of the eastern rim) these islands only drifted out a little way. It is plain that many of them fit into indentations in the adjacent shore and in one place, just above Castle Island, a peninsula was formed where one section did not quite break away from the rim. (See figure No. 14) To the north, near the mouth of Richmond Gulf, a secondary rim started to break off but only succeeded in tilting a little toward the center of the arc much as the Nastapoka Islands are tilted. The Richmond Gulf area behind this rim, slumped a little into the heated magma below. Apparently too, there were sections along the rim where hotter and more active streams of lava came to the surface, carrying away with them island chunks of rim that now are seen as the Baker's Dozen and King George Islands. If these islands are indeed a part of the Nastapoka group and fit into the gaps they should now be tipped at random angles or level rather than having the uniform tilt toward the center of the arc. It is hoped that this prediction

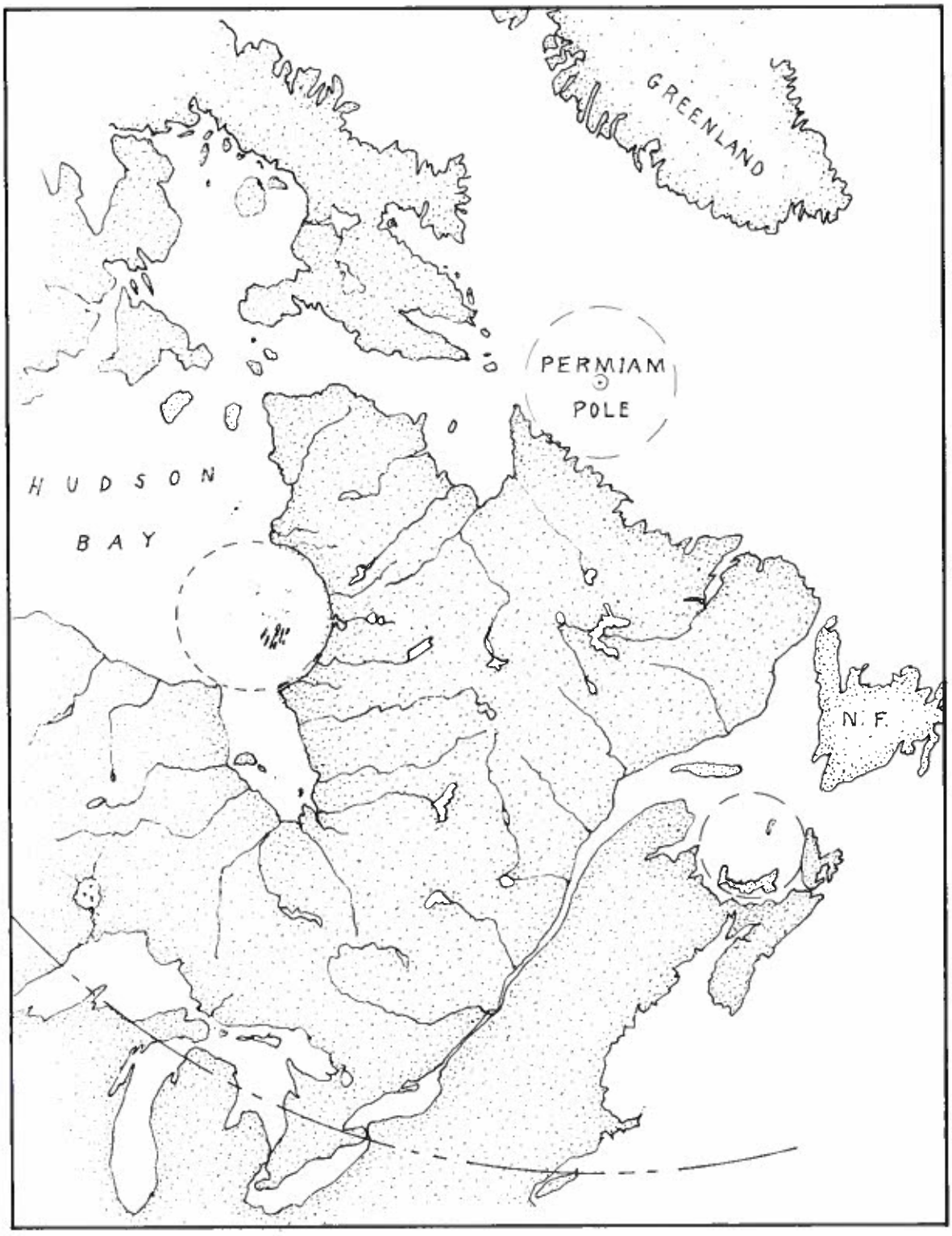


FIG. 12
Map showing drainage and other features of northeastern North America.

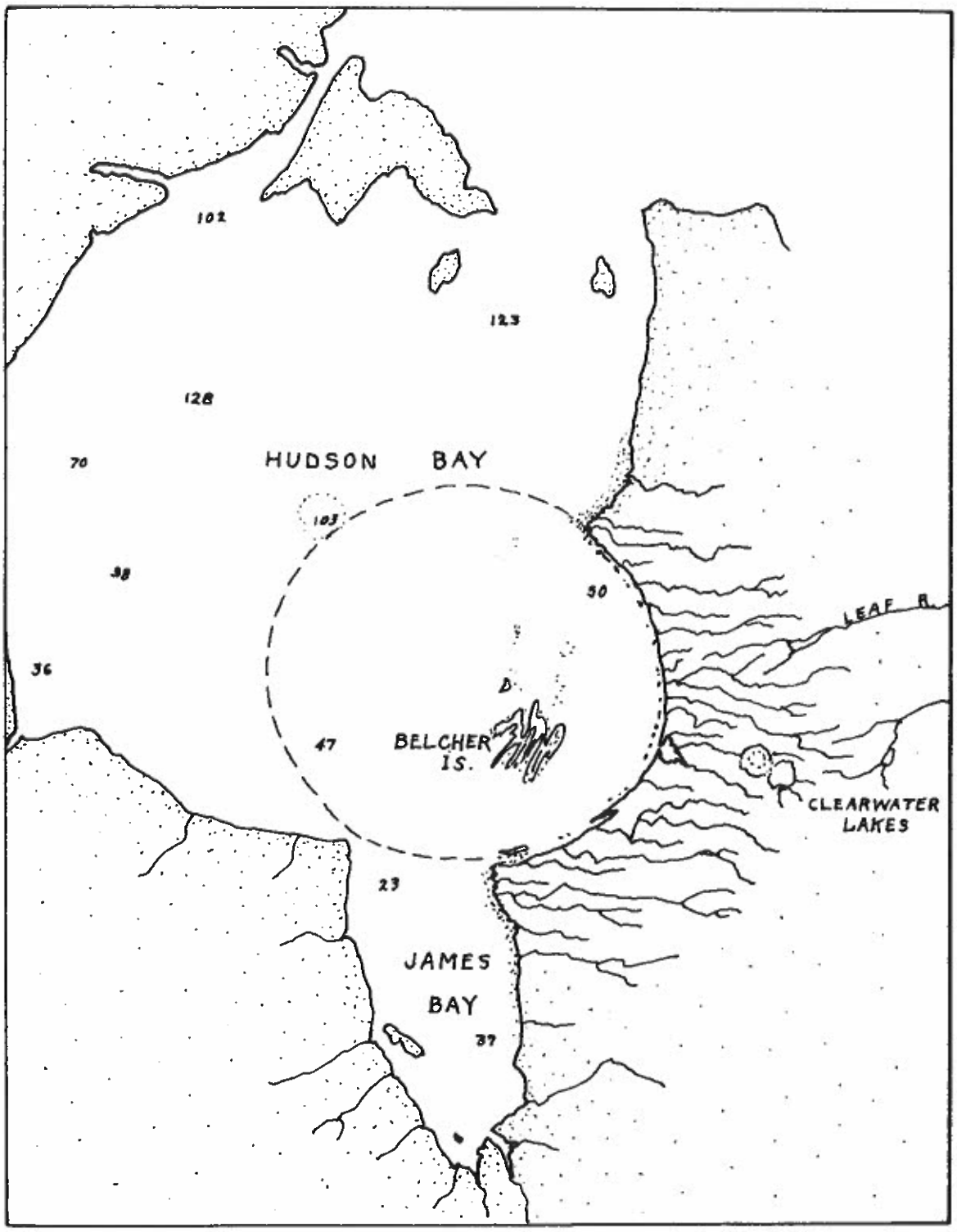


FIG. 13
Map showing Hudson Bay area including depth of water in fathoms, off center location of the Belcher Islands and the parallelism of the rivers entering Hudson Bay along the arc.

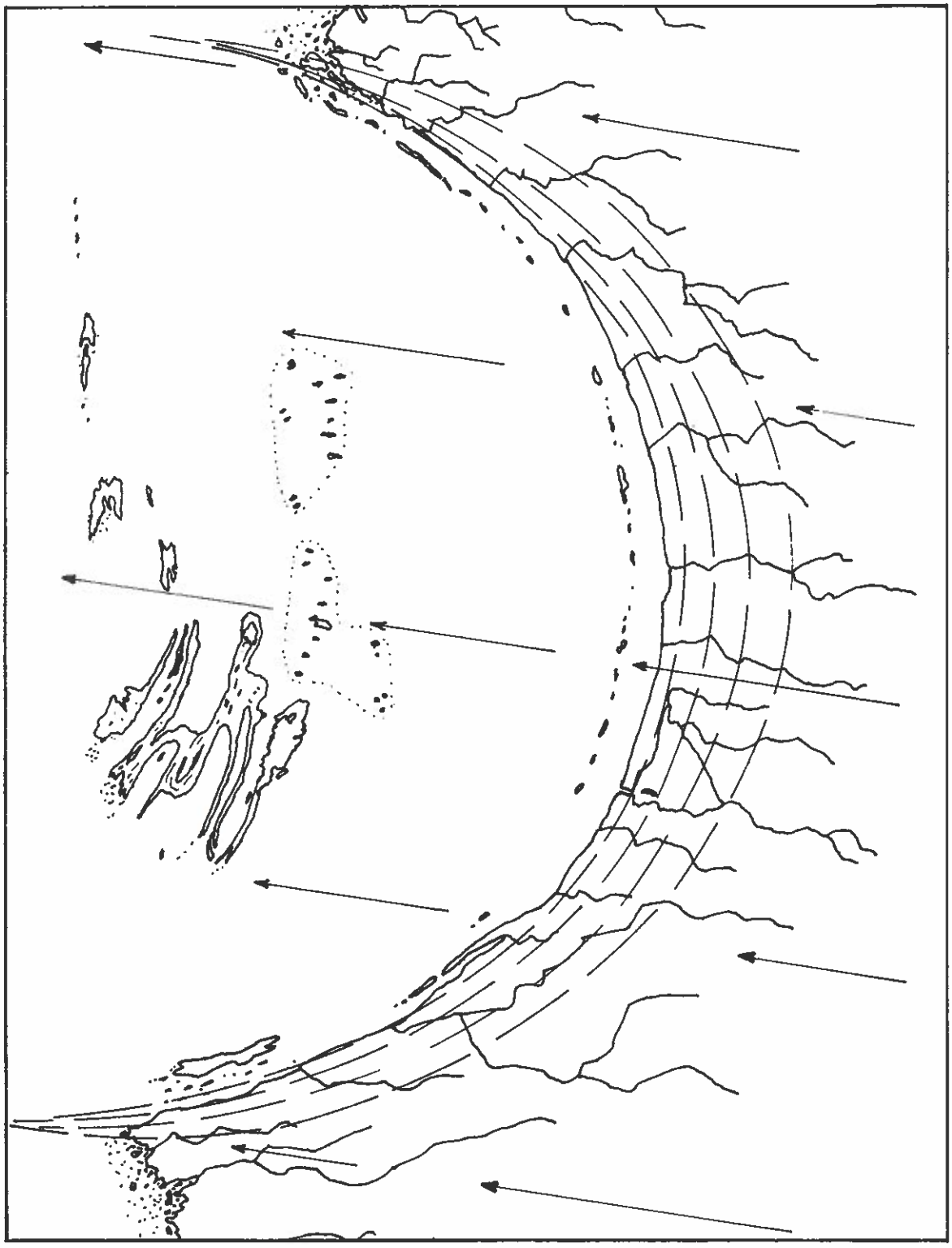


FIG. 14

Arrows showing parallel direction of rivers indicating direction of approach of striking body. Also the zig-zag nature of the rivers as they cross over and follow the circular faulting. These observations are from the large scale maps and not from field investigation.

may be verified by some future investigator. The lava caps on the Nastapokas we attribute to a dunking-under action as the huge chunks broke off the rim. It will be interesting too, if the Baker's Dozen and the King George Islands have these lava caps. How shall we explain them in orthodox fashion? If they have none, can we suppose that they did not dunk under? Have they got a lava coating on their sides? These are some of the questions that need answers.

The King George Islands lie about 65 miles off shore in an elongated group that parallels that section of the arc between the Hopewell Islands and the end of the Nastapoka chain. If pushed back in place they would almost exactly fill the gap in that part of the chain. (See Map) The Baker's Dozen Islands are apparently of the same origin. Except for four odd members, they are in a row and lie parallel to the center of the arc. They may have come out of gaps in the Nastapoka chain or were part of a rim section ahead of the Nastapokas. This may account for the fact that they drifted farther, about 80 miles from the Nastapoka chain. Apparently all of these drifting islands came to a stop because they met opposing currents coming from the other side of the convection cell.

All this will seem fantastic and incredible in the extreme to the formally trained geologist who has never been taught to think in terms of collision geology. Yet it is equally unbelievable to suppose that these islands fit this pattern by sheer chance, especially if field investigation proves that the rocks in these islands match those in the chain and the chain matches the adjoining shoreline.

Early in 1964 when the first draft of this manuscript was sent to Dr. Beals and a number of other scientists, a letter was received from Dr. Beals in which he pointed out certain errors in fact and interpretations which he considered in need of correction. He also included for my further study and use an undated bulletin put out by the Dominion Observatory called "Fossil Meteorite Craters," Vol. 5 No. 20, by C. S. Beals, M. J. S. Innes, and J. A. Rottenburg. In this bulletin, the Hudson Bay Arc (designated by them as the "Nastapoka Island Arc of Hudson Bay") is described as follows:

"These co-ordinates (80°-02'-W: 57°-40'-N) represent the center of curvature of an almost perfectly circular arc on the east coast of Hudson Bay, approximately 275 miles (440 km) in diameter (See figure No. 14). This is a conspicuous feature even on a world map, and many scientists and others have made the suggestion that it might have been due to the impact of a giant meteorite."

"On a moderately large scale map it is seen that over most of its length the arc is characterized by a screen of islands, of which the most important are the Nastapoka Islands, a chain over 100 miles (160 km) long, of average latitude 57 degrees. Geologic studies of the islands (Bell 1877-1878; Low 1900; Kranck 1950) have indicated that they are composed of *Precambrian sediments*, which sometimes extend to the mainland; throughout the length of the arc the sediments dip radially inward toward the center at angles of a few degrees. Students of aerial photographs have confirmed the radial direction of dip over the entire length of the arc and have also confirmed that in many places the sediments extend to the mainland where it is often possible to see the contact between the sediments and the granitic rock of which the mainland

is largely composed. When observed from a low-flying aircraft, the seaward dip of the sediments is a very striking phenomenon and, considered in connection with the above geologic and photographic evidence, suggests the existence of a deep circular basin in which great depths of sediments may well have been deposited. In addition to the off-shore islands already mentioned, there are numerous other islands near the center of the circle, the most important of which are the Belcher Islands south and east of the center. Where geologic information is available, the islands are composed of *Precambrian sediments*, often capped or interbedded with lava flows. It appears that, in contrast to observations on the border of the arc, the sediments on the more central islands are, in general, either flat lying or folded and do not correspond in dip to those on the arc. (G. D. Jackson private communication) In addition to the evidence of vulcanism on the islands, lava flows are also a feature of certain areas of the mainland near the coastal arc."

"On the landward side of the arc, hills normally rise to a height of several hundred feet; in places near Richmond Gulf the elevation is 1500 feet (460 meters) above sea level, which is suggestive of an ancient and eroded crater rim. The incompleteness of the circle on the west is, of course, a handicap to interpretation, and at present there is no evidence of an underwater continuation of the visible features of the arc. It maybe remarked, however, having regard for the very great age of the feature (600,000,000 to 1,000,000,000 years) that it would indeed be surprising if it had remained completely intact over such an immense period of time. If this is truly a fossil meteroite crater, we are fortunate in having such a substantial proportion of it remaining for study."

"There is a rather striking parallel between this feature and the well-known feature called Mare Crisium on the moon. Mare Crisium is an oval to circular feature, of average diameter 318 miles (509 km) and depth 8,000 feet (2440 meters), with what is believed to be a lava floor (Pl. 12). Although measures of altitude are not available for the rim, it is clear that the feature is surrounded by hills rising to a height of several thousand feet. When the phase of the moon is such that the sunlight terminator bisects Mare Crisium, its resemblance to the Hudson Bay arc is quite striking. Unfortunately, the size of the Hudson Bay feature and its great age are formidable obstacles to investigation. It would appear logical to look for a lava floor under the sediments, but their assumed great depth (3600 feet or 1100 meters near the coast and presumably much greater farther out) would make drilling very expensive. It is also quite probable that consolidation and alteration of the sediments would make it difficult by geophysical methods to establish the existence of a boundary within the basement. In spite of these difficulties, it is hoped to undertake gravity, magnetic, and seismic work in the area as soon as facilities are available for making measurements of this kind at sea."

In his letter accompanying the bulletin (quoted above) and in a subsequent letter, Dr. Beals emphasizes that the sediments of the islands in the basin are of later deposition although apparently still of Precambrian age. In his second letter he states that they are sandstones and limestones. To quote from his communication of October 17, 1964; "The sedimentary nature of these islands is clearly seen from a low-flying plane and may be studied in detail with

the aid of aerial photographs. This has also been verified by eminent geologists working on the ground (the necessary references may be found in the paper by Innes, Rottenburg and myself which I am sending you under separate cover). All of the island sediments as well as some of them which are attached to the mainland, are seen to dip in a seaward direction toward the centre of the arc as described in the paper mentioned above. In many cases they are capped or interbedded by lava flows suggesting a geologically disturbed region."

"In addition to the islands following the shore line of the main arc, the other islands of this general part of Hudson Bay of which the Belcher Islands are the most important, are also Precambrian sediments presumably laid down after the arc itself was formed."

"In order to see whether the dips of the sediments are correlated with the attitudes of the basement rocks and to see whether the basement itself was composed of lava or gneiss, we sank a drill hole in one of the islands west of Manitounuk Sound. Here the dip of the sediments was of the order of 7 degrees and we calculated that the contact of the sediments and basement should be encountered at 1200 feet. This was verified by the examination of the diamond drill cores which showed the actual contact to be at 1340 feet. The drilling was continued to a depth of 3414 feet and the cores from the basement rock were found to be of granite gneiss, similar to the Precambrian rocks outcropping on the mainland across Manitounuk Sound from the islands. It appears reasonably certain, therefore, that the islands are not 'pieces' of the mainland which have floated off on a lava support but that they were deposited in place on a sloping basement composed of granite gneiss similar to that making up most of the Canadian Shield. Their surface forms and separation from the mainland find their most logical explanation in terms of differential erosion."

"It is of course possible that a substantial part of Hudson Bay near the centre, may be underlain by a lava floor. If such a floor exists, it would probably be rather deep, on the order of many thousands of feet. Actually, as you are no doubt aware, Hudson Bay is a shallow sea and if the lava floor exists it is almost certainly covered by thousands of feet of sediments. Plans are now on foot to study this matter by seismic, gravity and magnetic methods."

"The age of the sediments is very great, of the order of a billion years and the formation of the arc is probably far in the past, at least hundreds of millions of years before the recent ice ages. This makes it unlikely, even if the arc was of impact origin, that the collision could account for the absence of glacial drift. If such a major collisional event had occurred so recently, evidence of it would be clearly seen in a rugged and elevated rim of several thousand feet in height and in the presence of great masses of debris surrounding the Arc. Since these are not seen (such remnants of a rim as now exist is of a few hundred feet only) there is little justification for the interpretation of the Hudson Bay Arc as a recent event."

It will be understood from the above quotations, that Dr. Beals is not in sympathy with the collision-drift theory as it may apply to the Nastapoka Islands and the Hudson Bay Arc, although his own solution for the Nastapoka chain, "Differential erosion" is somewhat less than clear. However, he is no doubt reserving his opinions for a time, until further information becomes available.

It will be noted in the above quotation that the rocks in these islands are Precambrian sediments that once extended to the mainland, which, Dr. Beals makes clear, are Precambrian granite gneiss.*

It seems that there is some difference of opinion about the kind of rock material in the islands and whether it is the same as the adjacent mainland. However, Dr. Beals makes plain that both are Precambrian in age although the island sediments were deposited long after the mainland rocks. He therefore reasons that even if the Arc was of impact origin, drifting of the islands was not possible.

If this is true, then we maintain that it is impossible to explain the glaciation found there by Uniformitarian geology. It is beyond belief that several Pleistocene glacial advances and retreats (as the orthodox geologist describes them) could have gouged out the hard Precambrian sediments from this basin and left the Belcher and Nastapoka islands in their unusual and curious configurations.

Dr. Beals is also quite certain that this basin must be filled with thousands of feet of more recent sediments.

This would mean that the Belcher Islands, the King George and Baker's Dozen, were all high mountain peaks and ridges that have been filled around and about with glacial sediments and finally, their tops all planed off at about 500 feet above the present sea floor. Still more difficult to explain, how was this platform of highly contorted stratified rocks and lava intrusions twisted into long loops and narrow strips and again, broken at sharp angles? What forces pitched these ancient rocks at all angles and then planed them all off to about the same level? Could ice work in all these ways?

It is our belief that very little sedimentation has occurred on the floor of Hudson Bay and that a nearly level floor of lava will be found underlying most of the waters of this basin. These islands of Precambrian sediments are now locked in this ancient sea of lava but more deeply than one might suppose. Thus, drilling on an island to 3414 feet may prove that a contact exists between the Precambrian sediments and the granitic gneiss at 1340 feet, but it does not prove that this island block is not immersed in lava. It seems only reasonable that if island chunks two to five miles wide were to break off such a crater rim as described, they would be much deeper than wide and float in the heavy magma much like an iceberg floating in water.

Dr. Beals seems to have gotten the impression too, that we thought this collision happened in recent times and he claims that in this event, it should have made a high mountainous rim that would still be much in evidence.

This was not the case. We did say that the last great collision which brought the Pleistocene to a close (producing all of the "ice ages" at once) centered around the Bermuda islands and caused a shift in the earth's axis to its present location. This caused tremendous oceanic flooding but it did not move the thick polar ice out of Hudson Bay, or the Greenland basin, or the ice out of the Great Lakes basins. The Great lakes are plainly, giant kettle lakes as are the tens of

* This is a very different material from sandstone or limestone. Dr. Cohen and others, have stated that the islands are granitic gneiss.

thousands of smaller kettle lakes around the western side of this old ice cap.* The Great Lakes held their ice in place while thick beds of gravel were thrown up against them by the oceanic flood. This is proved by the fact that nearly all of the streams around the lakes to the south and west, rise at the shore lines and flow away to the Mississippi system while the Great Lakes themselves, drain into the St. Lawrence River. Greenland retained its thick ice cap because it remained inside the arctic circle after the polar axis change.

Now as to the high crater rim that Dr. Beals feels should be present around a crater of this size: This reasoning appears to come from extrapolating large crater features from small ones. Baldwin has shown that explosion takes place nearer the surface as the mass of the striking body goes up and the large craters and maria on the moon are visible proof that this is true. The maria show plainly, that crater basins the size of the Hudson Bay Arc should fill with lava to within a few thousand feet of the rim and except for possible blow-back material, should produce little or no loose rim debris. In the case of the Hudson Bay Arc, it appears quite probable, in view of the glacial evidence, that the asteroid body struck on an ice cap 8000 to 10,000 feet thick so that the explosion took place at or above ground level. This would account for the absence of rim as well as rock debris, including glacial till.

The time element, when did this occur, is a difficult one to answer by field observation but when isotopic age determinations are made of the lavas in the crater basin, we should know. Dr. Beals and others seem to agree that the Hudson Bay Arc is Precambrian in age because it is located in Precambrian rocks. We fail to understand this reasoning. We see no reason why it could not have happened in Precambrian time or at any subsequent to Precambrian, up to as late as the Cretaceous. There is no visible evidence to prove that the Canadian Shield area has ever been out from under a blanket of ice long enough to accumulate consolidated sedimentary rocks. The advocates of Precambrian age are implying that all of the geologic column, Cambrian, Ordovician, Silurian, Permian and all of the rest up to the very recent, have been present but have been eroded away and are now resting somewhere on the floor of the deep ocean.

This theory, that the geologic column (as determined by fossil content) was, at one time or another, everywhere present over most of the land surface of the earth was ridiculed by its opponents as the "Onion Coat" theory. The idea was (according to its opponents) that in every age, a uniform blanket of sediments had been spread over each of the continents and while later erosion may have removed many of these great geologic sections, that they had nevertheless once been present. Today, most geology text books avoid the subject or deny that it is true but in other sections of the book it is implied as in the case above. To say that the Hudson Bay Arc is Precambrian in age because it is in Precambrian rocks is to imply that all subsequent formations in the geologic column have been eroded away. Obviously, if a collision occurred there today or next year, it would be located in Precambrian rocks. This kind of dogmatism is probably a product of formal education.

Apropos of this, in a recently published text book, PRINCIPLES of GEOLOGY, by Gilluly, Waters & Woodford, we read: "Cuvier's discovery of the extinction of some species of animals

*(See Meteoritic Kettle Lakes, Kelly, 1963)

and the rise of new ones led him to the erroneous conclusion that there had been a series of catastrophies in geologic history. These, he believed, destroyed all existing life, and following each a whole new fauna was created: This doctrine, called Catastrophism, was doubtless inspired by the Biblical story of the Deluge. Part of Cuvier's error lay in confusing facies faunas with new creations, for in the Paris Basin a continental environment commonly followed a marine one but part of the confusion, no doubt, was due to the human prediliction to fit his ideas into those current at the time. This trait is still with us, in science as well as other activities, and serves too often to color judgments that should be objective."

As indicated above, we believe that this collision could have occurred at any time from Precambrian up to perhaps the Cretaceous but let us follow through on two possible hypothesis: First, that it occurred in Precambrian time. Second that it occurred at the same time and by the same cause as the Pacific collision.

If it occurred in the Precambrian, we must assume that the area was covered with a thick blanket of ice and had already been eroded down to near its present level and that the ice remained there after it reformed over the crater and did not move until it melted in place at the end of the Pleistocene. Under this hypothesis we fail to account for polar cap wanderings and continental drift.

The second hypothesis we elaborate as follows: If we assume from the glacial evidence in Africa and South America and from the other evidence of drifting, that these two continents were once joined along the Mid Atlantic Ridge, then we find one polar cap centered at Tristan da Cunha in the South Atlantic and the opposite one in the North Pacific with its edges just touching Japan and the Aleutian Islands. Now if we further assume that the Canadian Shield was located under this north polar cap in Permian time and before the Pacific Collision, then perhaps we can logically account for the impact scar (Hudson Bay Arc) as having been made on the northern edge of the collision pathway following which, it drifted to its present location along with the rest of the Canadian Shield. To make sense, the axis of the earth had to move with it to this new location, so that the ice cap formed again over the crater basin. This put the south polar axis in the South Indian Ocean between Australia and Antarctica. (See figures No. 18 and 19)

Meanwhile, the new ice cap protected the Hudson Bay Arc from further erosion and weathering until the Bermuda Collision which changed the axis of the earth to its present location but did not move the ice out of Hudson Bay, the Great Lakes or the Gulf of St. Lawrence. (See Meteoritic Collision, A Dynamic Force in Earth History, Allan O. Kelly 1963)

In discussing the Gulf of St. Lawrence we mentioned the fact that the glacial till on Prince Edward Island and the surrounding mainland was laid down as a blanket and shows no directional movement of the ice. Since a continental ice cap cannot acquire boulder gravel from high canyon walls as mountain glaciers do, we reason that the oceanic flood which accompanied the Bermuda Collision picked up the thin edges of the glacial ice that pushed into the sea off the coasts of New England and Nova Scotia and threw this ice, with its boulder-filled underside, upon the relatively flat top of the ice cap that covered the Gulf of St. Lawrence. There is no

other way, it seems, to explain this type of blanket drift and the sometimes intervening driftless areas. Relative to this question, we had quite a heated argument with a young geologist in charge of the geology section of the Museum in St. John, Nova Scotia. He had spent several summers mapping Prince Edward Island and the adjacent shoreline and had never noticed these anomalies. To this young geologist drift was drift; he was mapping it along with the underlying formations and how it got there was a matter of speculation and therefore out-of-bounds for the scientist.

It is well known that glacial ice can pluck angular boulders out of the bed rock and carry them along, but if there is no movement of the ice, nothing can be picked up and nothing can be dropped. Such a blanket of ice preserves the bedrock from weathering, probably with little change in millions of years. Thus the Canadian Shield has been protected from the powerful agents of weathering such as rain and sun, the air and its oxygen, the prying effects of roots and plant acids that break up the rocks in warmer climates.

Another interesting feature of impact craters is a study of the uneven blast effects as a means of determining the direction of approach of the striking body. Most impact craters show the effects of uneven blast, even small craters. Sections of the rim may be blown away or large heaps of rock thrown out in certain sectors beyond the rim. This is probably because meteorites are seldom perfectly round and seldom fall at right angles to a perfectly flat earth surface. Large lunar craters usually show this uneven distribution of ejected material, if we look closely, although the general impression is that they are round. Practically all terrestrial meteorite craters show this lack of symmetry in outline and in the distribution of ejecta. For example, the Arizona Meteorite Crater is not round but rather a square with the corners rounded off, and the ejecta is concentrated on the northeast and southwest sides. (See figure No. 15) Another example, the Dalgaranga Crater in Western Australia* is quite small, being only 75 feet in diameter and about ten feet deep. It was made by an iron meteorite striking in almost perfectly flat ground. It blasted a crater out of very hard laterite rock of uniform quality, yet it made a crater that is not round and threw out the rock in a very uneven pattern. (See figure No. 16)

The Hudson Bay Arc is not perfectly round, and while its rim features cannot be extrapolated from small crater forms, it does show strong signs of crescent faulting that may be compared to similar faulting around Mare Crisium and Mare Humorum.

The direction of approach is indicated by several features as having been from a high angle and a little south of east. In the central sector east of the arc, all of the lakes are elongated in an ESE direction, while to the north and south, the lakes gradually lose their directional elongation and become (near the tips of the arc) completely irregular in shape. (See fold map)

This would lead one to believe that the ice was literally pushed across the bedrock in the eastern section, gouging out the rock basins and moving the whole mass somewhat up-grade and over the divide onto the Atlantic slope. In fact this heavily glaciated country is so nearly level that one of the large rivers, Leaf River, heads within 18 miles of the rim of the Hudson Bay Arc and flows through Lake Minto (surface elevation 450 feet) to the northeast

*The author visited Dalgaranga Crater along with Dr. & Mrs. H. H. Nininger in February of 1959.

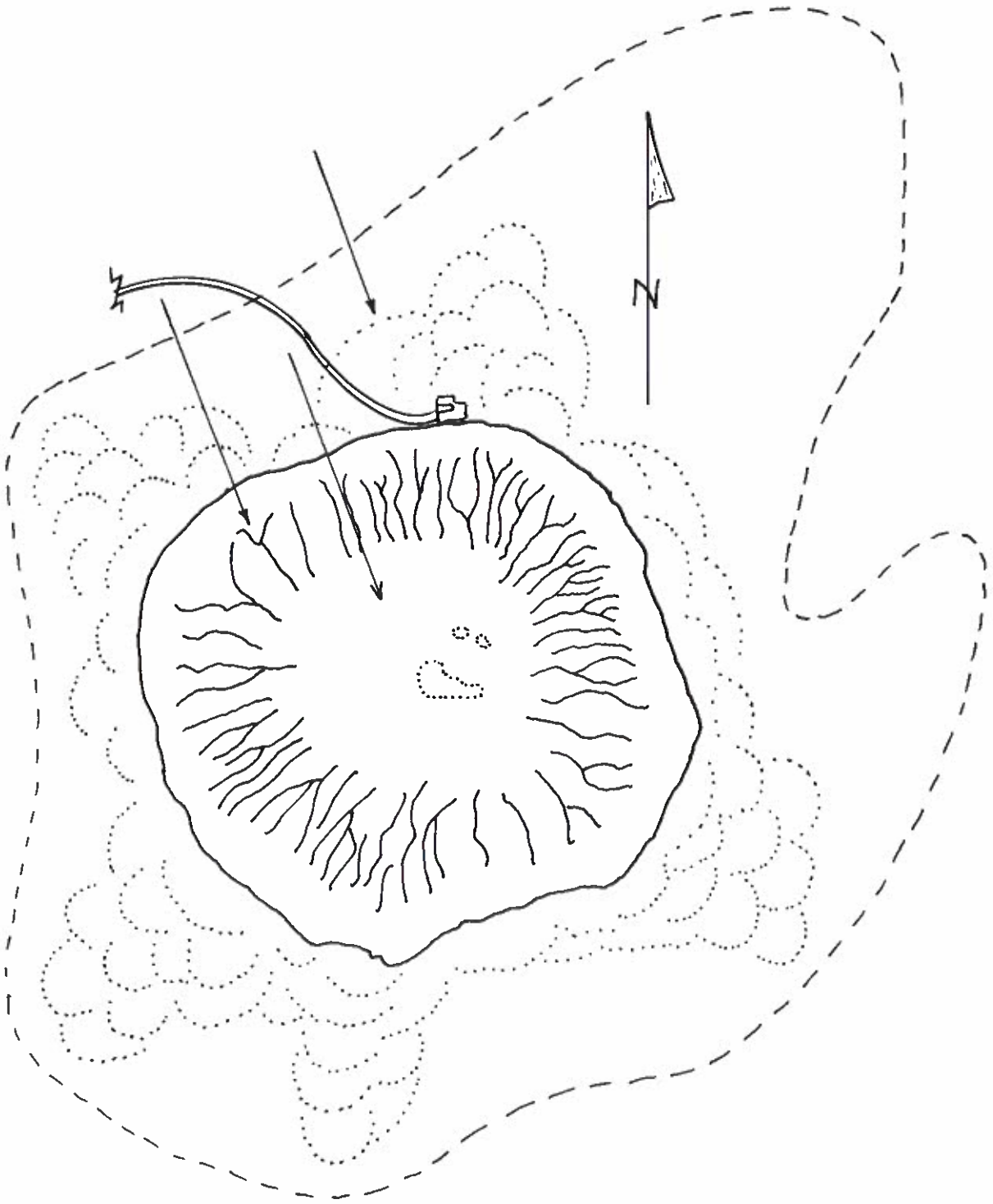


FIG. 15
METEOR CRATER, ARIZONA
The solid lines show the rim of the crater and the erosion gullies inside the crater. The dotted lines indicate the bulk of the rock debris thrown out and the dashed line shows the outer limits of this ejecta.

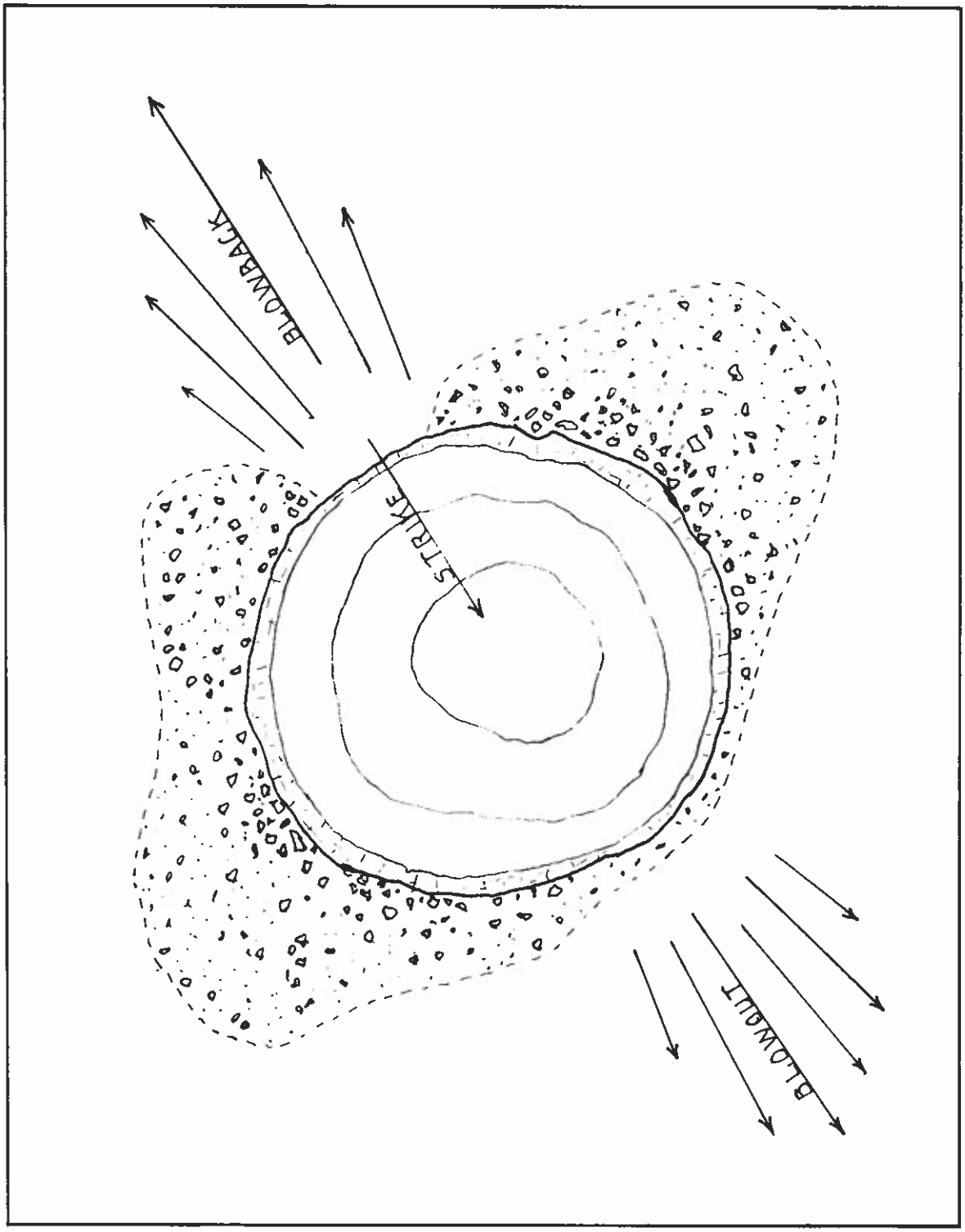


FIG. 16

Dalgaranga Crater, Western Australia, showing the irregular distribution of ejecta and the direction of meteorite approach. Heads of arrows indicate distance to which chunks of laterite were thrown. No rim was left on the blow-back side.

into ungava Bay. (See fold map and figure No. 13) The rivers on either side of Leaf River have their source far inland and flow west into Hudson Bay thus indicating the near-level nature of the terrain. This elongation of lakes in the center would seem to indicate a blow-back in that direction which moved all of the ice down to hard bedrock but without any accompanying lava ejecta. At the same time, the irregular shape of the lakes along the north and south tips of the arc would seem to indicate that lesser blasts were directed in this direction, cutting away the top layers of ice but not removing it down to bedrock and therefore no directional grooving is seen. (See fold map)

Another structural feature, pointed out earlier, is the marked difference of the coast lines north of the arc and to the south in James Bay. Here the glaciated islands fade into the sea and are scattered in a completely random nature without sharply defined coast line as compared to the smooth and well defined arc and its equally smooth and paralleling chain of islands. This evidence, together with the glacial evidence, is reasonably good proof that the striking body exploded in the ice above the basement rock.

A second kind of evidence pointing to the directional approach of the striking body is the parallel flow of rivers in a general westward trend, whether at the center or near the points of the crescent arc. (See figure No. 14) The zig-zag nature of the rivers and especially in the section close to the rim of the arc indicate multiple crescent faulting paralleling the coast line of the arc. The rivers tend to follow the faults for a few miles and then cut through the ridge to the next fault but in general their courses are parallel to the direction of approach. This is especially noticeable toward the north and south ends of the arc where the rivers begin to more nearly parallel the coast line. The Great Whale River shows this zig-zag and paralleling trend in marked degree. Is this peculiar and unnatural trend of rivers to be attributed to "differential erosion?" It is our guess that this arcuate structure closely resembles Mare Crisium which shows a crescent arc of mountains coming to points that in turn, point toward the direction of approach. It shows that less explosive energy was directed toward the sides and less undercutting by up-welling lava. If the Hudson Bay area had been a high plateau or mountainous area at the time of impact, it might have resulted in a huge mountain arc like that of Mare Crisium, rather than a chain of islands and a surrounding series of circular faults with the radial faults represented by the rivers. (See figure No. 14)

At the southern end of the arc we find the largest and longest island in the chain. It is called Long Island, and with the addition of the small islands behind it, fits the mainland very nicely. (See map) It will be noted that these small islands behind Long Island are arranged in chains also, and that the whole group including the big island, appears to have moved about four miles northward along the coast as well as out away from the mainland. This was probably due to the movement of the lava toward the center of this huge convection cell.

Of further interest is the fact that these islands appear to be of the same geologic formation as Tukarak, Mavor, Innetalling, O'Leary and Broomfield Islands on the near side of the Belcher Island group. (See photo Nos. 9, 10, 11)

In summary: The clear-cut symmetry of this mighty arc, its uniqueness, its fault pattern

and its many other kinds of supporting evidence, make any explanation other than meteoritic impact, exceedingly unlikely. Perhaps the best way to convince the reader of the validity of this statement is to invite him to explain these features by the generally accepted Uniformtarian theory.

PHOTO NO. 9

Tukarak Island area, probably a part of Mavor Island as near as could be located by personnel in the Office of Department of Mines, Ottawa, Canada. Apparently metamorphic rocks folded and tilted until the strata are almost vertical.

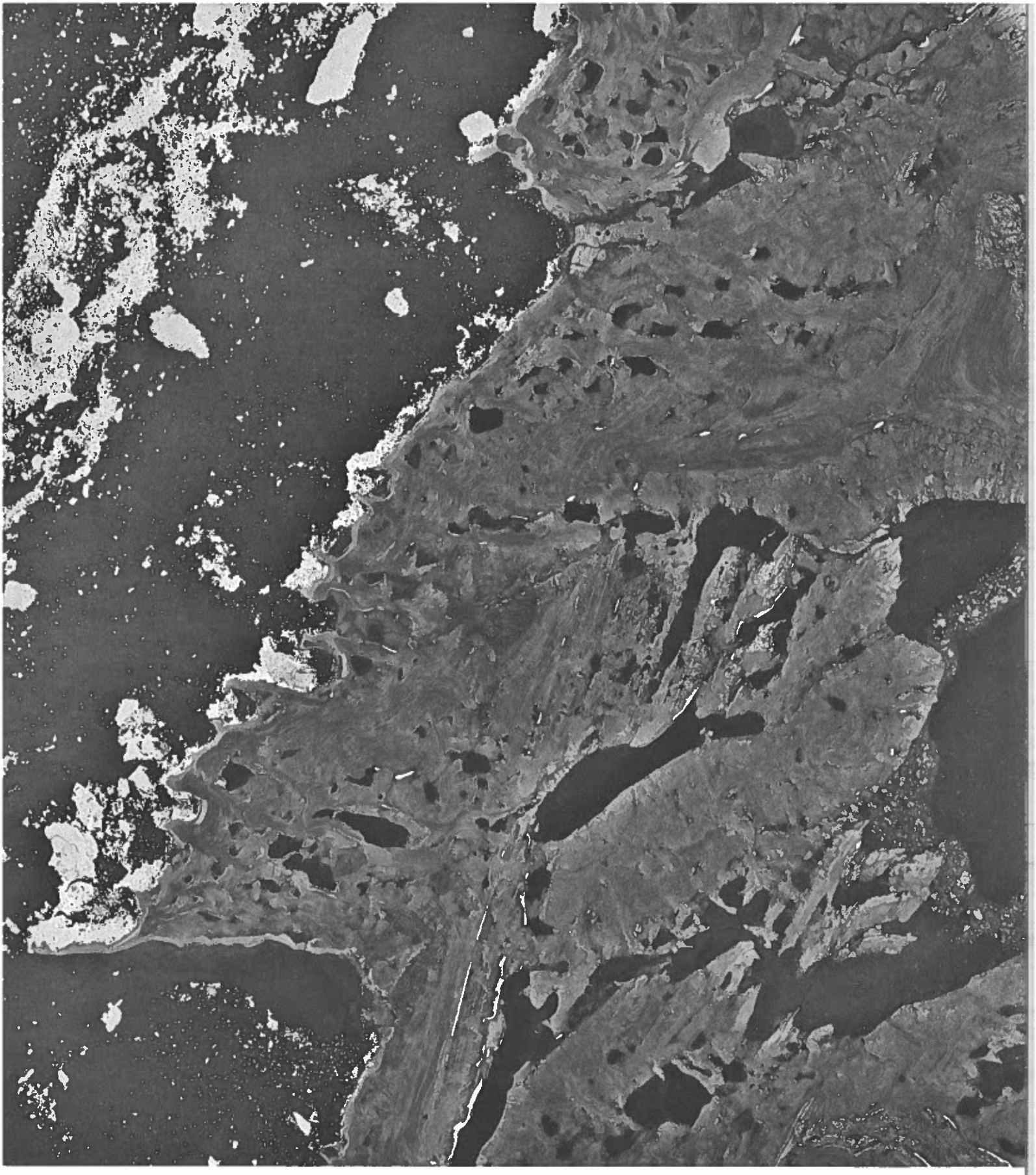


PHOTO NO. 10

A part of Tukarak Island, most eastern of the Belcher Island group. Flying height 17,000 feet. Some glacial drift (boulder gravel) can be seen in the water, right center of picture. Drift ice is seen in the channel on the other side.

PHOTO NO. 11

Islands in the channel between Long Island and the southern tip of Hudson Bay Arc. These islands appear to be of the same formation as Tukarak Island in the Belcher Island group.

ASTRONOMICAL CONSIDERATIONS OF COLLISION-DRIFT

According to Baldwin, the larger the meteorite, the less it penetrates before exploding. Beginning with small meteorites at a given velocity, he shows that as the mass increases the meteorite must explode closer to the surface of the ground and at about 60 miles in diameter, the meteorite will explode at or above the surface. (MEASURE OF THE MOON, Baldwin, Table 18, pp 177) From this he reasons that as the striking objects get still larger, a delayed action comes into play in which the leading edge or nose of the meteorite begins to explode, sending shock waves back through the body of the meteorite (roughly at the forward velocity) which causes a continuous explosion or spalling off of the outer surface, most of this energy directed parallel to the surface of the ground. With nearly all of the energy given over to disintegration by shock wave and most of this directed toward the sides, it would seem doubtful that any lava would be produced in the crater. This, of course, fits Baldwin's theory of "dry crater" formation on the moon. However, the earth with its mantle of air, presents a very different problem. But in either case we cannot accept the "dry crater" theory.

A somewhat different explanation in contrast to the shock wave theory would be that as the size of the meteorite goes up, a time-lag develops in the air escaping around the sides of the object, so that a column of compressed air is built up ahead of the meteorite. Here, pressures may reach into the millions of atmospheres and the temperatures to such heights that the iron or rock in the meteorite is almost instantly vaporized. We doubt the possibility of a shock wave breaking up an iron meteorite, although a stony-iron meteorite might well be disrupted from this cause.

It appears more likely, that on the earth where air is available to compress and heat, that a cone or jet-stream of exceeding high temperature would precede the meteorite, melting a hole into the earth much as an acetylene flame burns its way through an iron plate without much heat loss to the adjoining metal. (See figure No. 17)

One might assume many different sizes, velocities, and kinds of material that might be needed to produce a crater like that which we see inscribed in the shore of Hudson Bay, but in any event, the show must have been spectacular. The two-mile-thick icecap must have disappeared like magic in an explosion beyond human conception. White-hot gas, later turning to clouds of steam, and air shock waves would leave the spot at speeds roughly equal to the striking velocity. In a few seconds, perhaps 10 to 15, the asteroid would be reduced to vapor and a hole burned into the earth perhaps two to three diameters of the striking body. Assuming an iron meteorite of 15 mile diameter and a velocity of 20 mps, it might well penetrate 30-40 miles. This was probably followed by a gigantic fountain of white-hot lava that was blown directly back out of the crater hole in the direction from which the meteorite came. This stage may have lasted for hours, the extremely hot material rising to heights of at least 100 miles and spreading far and wide before falling again as a fine dust or sand. Much of this very finely divided material could have been carried entirely around the earth as was the dust from the Krakatoa volcanic explosion in the East Indies in 1883. In minutes, the heat spread out under

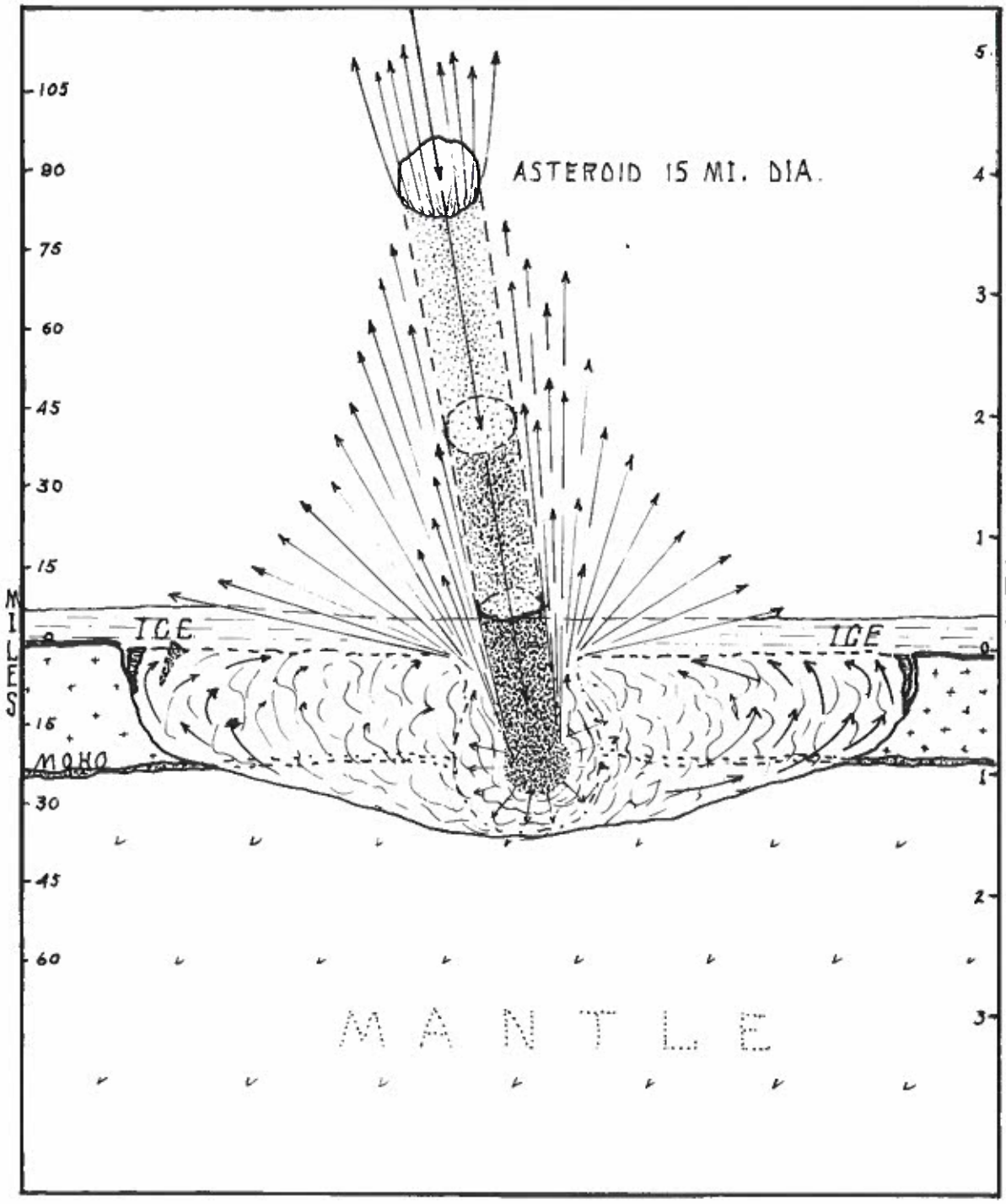


FIG. 17

Proposed four stages of a 15 mile in diameter body entering the earth's atmosphere. 1. Compression of air to high temperature. 2. Blasting away ice cap. 3. The vaporization of the body and an equal amount of the earth's crust. 4. The majority of the energy went to the blow-back and the production of a huge pool of lava.

the crust and formed a huge convection cell and as the heat rose to the surface, a crater some 288 miles in diameter was formed and filled with molten magma. As the heat penetrated outwardly, the temperature went down until the final result was a thick, viscous lava into which the last remnants of the crater rim fell and slowly drifted toward the center of the convection cell. Some chunks may have tipped over but most just slid down the crater wall, dunked under a bit and then rose again and drifted out a few miles from the rim. Most of them tipped a little toward the center of the crater because the surface lava was moving outward as the lava below moved upward. In some sections along the rim the lava was more liquid, as mentioned earlier, and here the island chunks were carried out much farther, forming the groups of islands known as the Baker's Dozen and the King George Islands. To the west of the King George Islands, another group called the South Sleeper Islands appear to have drifted down from the north section of the rim, at least they are strung out in that direction. They have rough irregular shaped coast lines and appear to more nearly match the Belcher group.

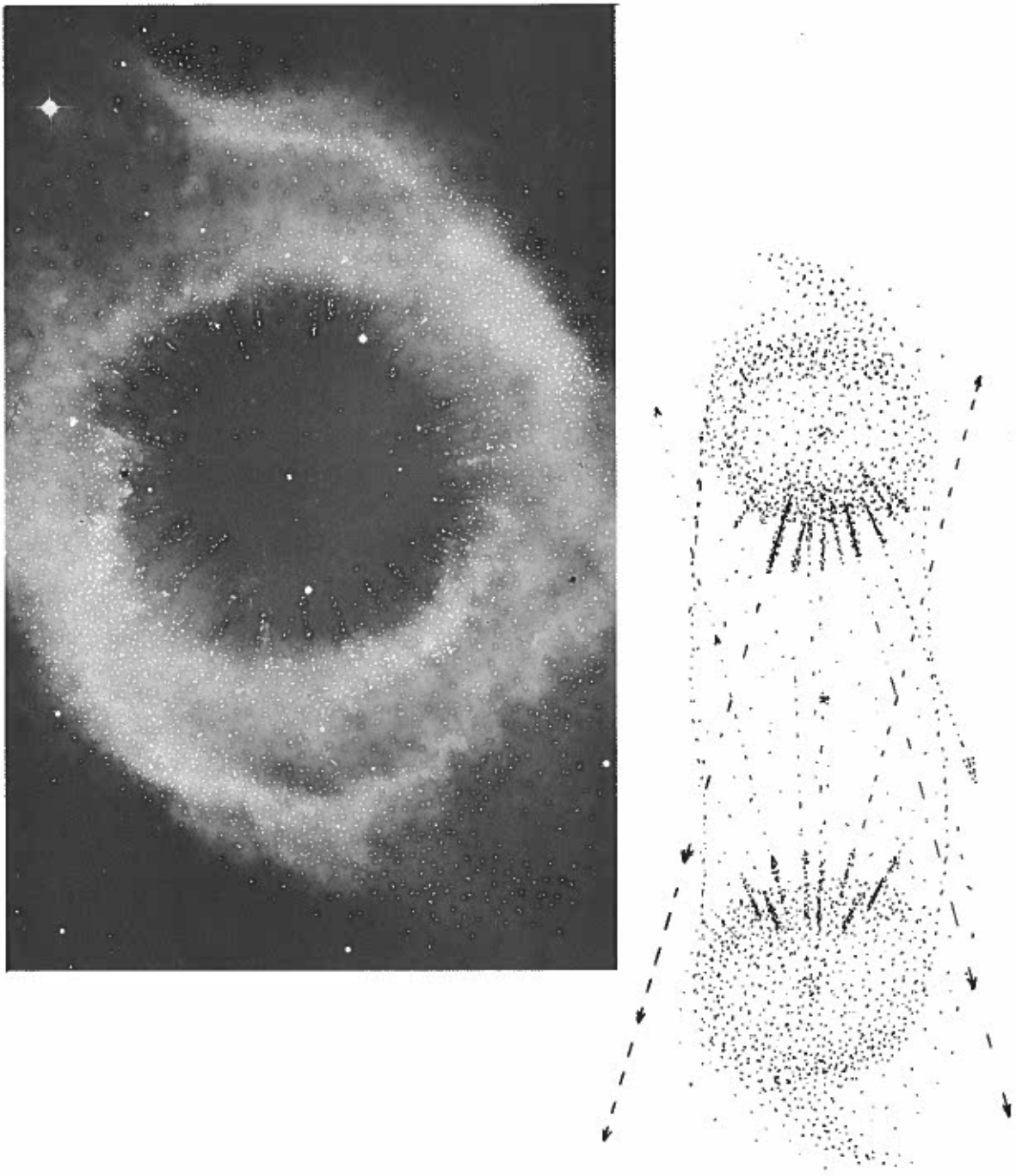
Another inference that may be drawn from the crescent shaped faulting around the Hudson Bay Arc is that it was made by a single large body. If it had been made by a number of smaller bodies striking in quick succession as we have proposed for the Mare Imbrium crater then there would have been many intersecting and smaller circular faults. It may well be, however, that the Clearwater Lakes, which lie in the line of flight only about 70 miles ESE from the center of the arc, are of the same fall. Their rims are joined by a screen of islands and the larger lake (20 miles in diameter) has an elevated ring similar to that found in the Ries Basin in Bavaria, Germany.

It is our belief that most large collisions have been of cometary origin and our reasoning is simple; that the earth is in a very good position to get hit by comets as they pass around the sun, much more so than by asteroids. This fact is borne out by the actual falls during historical time, which were in most cases a rain of many objects. Also, the more ancient fossil crater, where they were of a size sufficiently large to remain visible for long periods of time, have been multiple falls.

Astronomers will no doubt disagree with this proposal for it has been widely accepted that comets are nothing more than tenuous gases and cosmic dust. This idea gained widespread acceptance because a comet was once seen to pass across the disk of the sun and no dark objects were revealed. Also, stars have been seen through the heads of comets with little if any diminution of brightness. Another confirmation of their fragile and tenuous nature is that comets do not exercise any appreciable perturbing influence on the planets or their satellites. In spite of this, there is some evidence that comets contain solid material of asteroidal size. Some solid masses must be present to hold the dust and more tenuous gases, and the nucleus of at least one comet was seen to separate into two parts one trailing far behind the other. This must indicate some solid matter. It has been shown too, (See Larousse Encyclopedia of Astronomy Page 236) that the average width of all comet heads observed is about 80,000 miles, so it would seem that a few dozen objects from 10 to 50 miles in diameter might be very difficult to see, even with the best of telescopes, in such a brilliant cloud of gas. What we have here is a curtain of light

that can be very effective; a kind of curtain sometimes used in outdoor pagents at night. As I write this in my study, I can look outdoors through a split bamboo curtain of needle sized splints. If I focus my eyes on the curtain I see only curtain, but if I focus my eyes on the objects outdoors I see them quite plainly and the curtain is hardly noticed. In the same way we probably see a star through the nebulous head of a comet that may contain thousands of chunks of solid matter. It is quite likely too, that it would be impossible to see a 50-mile diameter object at a distance of a few million miles for it is well known that the largest telescopes cannot resolve objects on the moon less than a mile or two in diameter. In further opposition to those who claim that there are no large or solid objects in a comet's head we cite the fact that there have been no large comets in this century and since photography has become an important tool in the field of astronomy. In the 19th century there were several large comets seen to have solid nuclei. In October of 1858, G. P. Bond of Harvard Observatory made a sketch of Donati's comet as seen in a 15 inch refractor. This drawing shows a sharply defined nucleus with a long dark shadow cast through the tail of the comet. In 1874 a detailed drawing was made of Coggia's comet by Leopold Trouvelot, which showed a bright nucleus with a long, dark shadow, splitting the tail in half. (See Sky & Telescope, May, 1964, pp. 283.) The great comet of 1882 and the still larger one of 1843 (the latter seen in daylight) were so bright that no dark nucleus could be seen, yet there must have been solid masses of rock or iron to hold this gaseous material together by gravitational force. Actually, the gases must be in the form of ice frozen to the surface of the rocks or iron bodies in the head of the comet. As the comet nears the sun the ice vaporizes and is driven off as a gigantic tail, lost forever to this particular comet. It may be, however, that long-period comets traveling through the supercold regions far removed from the sun, gradually pick up molecules of various kinds of gas and return to the sun with a fresh coating of ice to be lost again in another grand gesture.

According to Dr. Otto Struve: "The great comet of 1882 passed at a distance of 500,000 km from the sun and must have been subjected to temperatures of at least 4500 degrees kelvin, sufficient to vaporize a body one meter or more in diameter. The comet's brightness did not change noticeably, and hense it must have been fairly large. However, it could not be seen when in front of the sun, so that the diameter could not have been more than 70 km ." (See ASTRONOM OF THE 20th CENTURY, Struve & Zebergs, pp 163) Dr. Struve further states that there are not only thousands of short period comets within the solar system but also great numbers of long period comets whose orbits reach out distances close to the nearest star, some having return periods in excess of one million years. He quotes Van Biesbroeck as having computed the orbit of Comet Delavan as an ellipse with a semimajor axis of 170,000 astronomical units and a period of 24 million years. "For Comet Morehouse (1908) Van Biesbroeck found that the original orbit was a greatly elongated ellipse with a period of about 500,000 years." Dr. Struve further states: "Collecting all available information, Oort found that there is a decided maximum of frequency among cometary orbits having major axes of about 150,000 a.u., which is not very different from the distance to the nearest star. This does not mean that the comets are interstellar. On the contrary, Oort believes that they must be members of the



BIRTHPLACE OF COMETS?

Does this picture record a moment in time when a whole family of comets were born?

Can this doughnut-shaped nebular cloud represent the cataclysmic collapse and pulsation of a lens-shaped nebula into a dense central sphere followed by explosion of the nucleus against the infalling rim of the cloud and a secondary implosion of thousands of cometary jets rebounding off the inside of the doughnut?

Extending the lines of these tiny jets, we see that they all focus near the center but if we could view this nebula edgewise, we might see that these jets diverge to some extent from the central focal point. There would be, however, perturbating influence from close approaches with other jets and from the mass of the ring cloud. Such gravitational force might pull them into orbits around the central star that would form out of those comets colliding at the center.

solar system, because they share the motion of the sun through interstellar space."

If this be true, it is not unlikely that the earth has experienced several major encounters with comets since the dawn of Precambrian time, for radio-age-determinations indicate that the Precambrian rocks in Canada go back 2500 million years. In any event, man has only observed comets with good equipment for a few dozens of years so that little is actually known about the hard-core materials in comets. Therefore, to say that a comet is nothing more than tenuous gas and dust is to speak from very limited knowledge and from an infinitesimal speck of experience in time. The point we are trying to make is that there are probably tens of tousands of comets that man has never seen that have kept on returning to their host star, the sun, and the earth and all of the other planets are in a good position to get hit and have been hit, down through the several billions of years of planetary history. The collision scars are plain to see on the Moon, Mars and to a fainter degree on Jupiter and Saturn. The earth scars are here to investigate at little cost and physical effort; it only remains for men to clear their minds of academic prejudice.

With all of the above evidence in view, the importance of the Hudson Bay Arc can hardly be over-emphasized. Here we have an intermediate sized impact scar or crater, that we think offers unmistakable evidence of collision-drift; a stepping stone between the small, known craters, and the gigantic ocean basin scars, and the whole tied in with the collision-drift evidence on the moon.

THE DYNAMICS OF CONTINENTAL DRIFT

Returning to continental drift as a world-wide phenomenon resulting from a major cometary collision on the Pacific hemisphere of the earth, we shall try to draw a word picture of what might have happened, using what physical evidence we have as a basis of reasoning, and, we hope, a reasonable knowledge of the physical laws.

First, we shall assume that the earth was rotating in a counter clockwise direction as it does today and certainly, in the same counter-clockwise direction around the sun. *Second*, that the Pre-Permian polar axis was tilted to about the same degree as at present because the glaciated area of the Tristan da Cunha polar cap which covered much of South Africa and South America was about the same area as our present polar caps. We prove this by pushing the two continents back together and finding a circular glaciated area. *Third*, we propose that the approach of the comet was from the rear and down at an angle of about 60 degrees. This reverses the direction of approach as proposed in our first manuscript but we have found what appears to be a good physical reason, or reasons: One, that the largest objects in a comet head should be in the lead because of their gravitational mass and so should strike first. Two, that the curvature and alignment of the large arcuate structures in the Pacific and their tensional troughs, indicate this direction. *Fourth*, that every continent and island mass drifted to some extent, more or less, except the Mid-Atlantic-Ridge. The Mid-Atlantic-Ridge represents the irregular, broken crack in the crust of the earth. *Fifth*, that the continents and large island chunks in the polar regions tended to rotate around the polar axis but that all of the continents tended to rotate to some degree simply because the earth is a sphere and because the striking bodies produced a certain amount of "English on the ball," as imparted by a tennis racket to a tennis ball, to cite a well known example. *Sixth*, that many mountainous islands along a mountainous coast indicate longitudinal rupture of a mountain range that had just been built by lateral pressure. Continental masses pushed together by drift mechanism would pull apart again and drift away as a group of islands. If we stop to think about it a bit, we must realize that there is no other rational means of explaining the origin of such islands. It cannot be shown, in many cases, that their high steep walls were made by either ice erosion, water erosion or the more recent "differential erosion." The orthodox geologist must fall back on such speculations as graben faulting or tectonics.

If we start *our speculation* with a north pole opposite Tristan da Cunha we find it located at 165 degrees east and 35 degrees north. (See figure Nos. 18, 19) A measurement of the south polar cap of Pre-Permian time shows a radius of about 1300 miles of glaciated area. This is roughly the same size as the earth's present ice covered polar caps if we average the two. Therefore, the Permian north polar cap was well within the pathway of the cometary train which moved across the earth almost from pole to pole. This direction is indicated by the 1,600 mile long Hawaiian chain and by other paralleling chains of undersea mountains in the South Pacific such as the Austral Island chain and the Tuamotu Archipelago which is really a parallel chain if one takes into consideration the long submarine ridge these islands rise out of in their

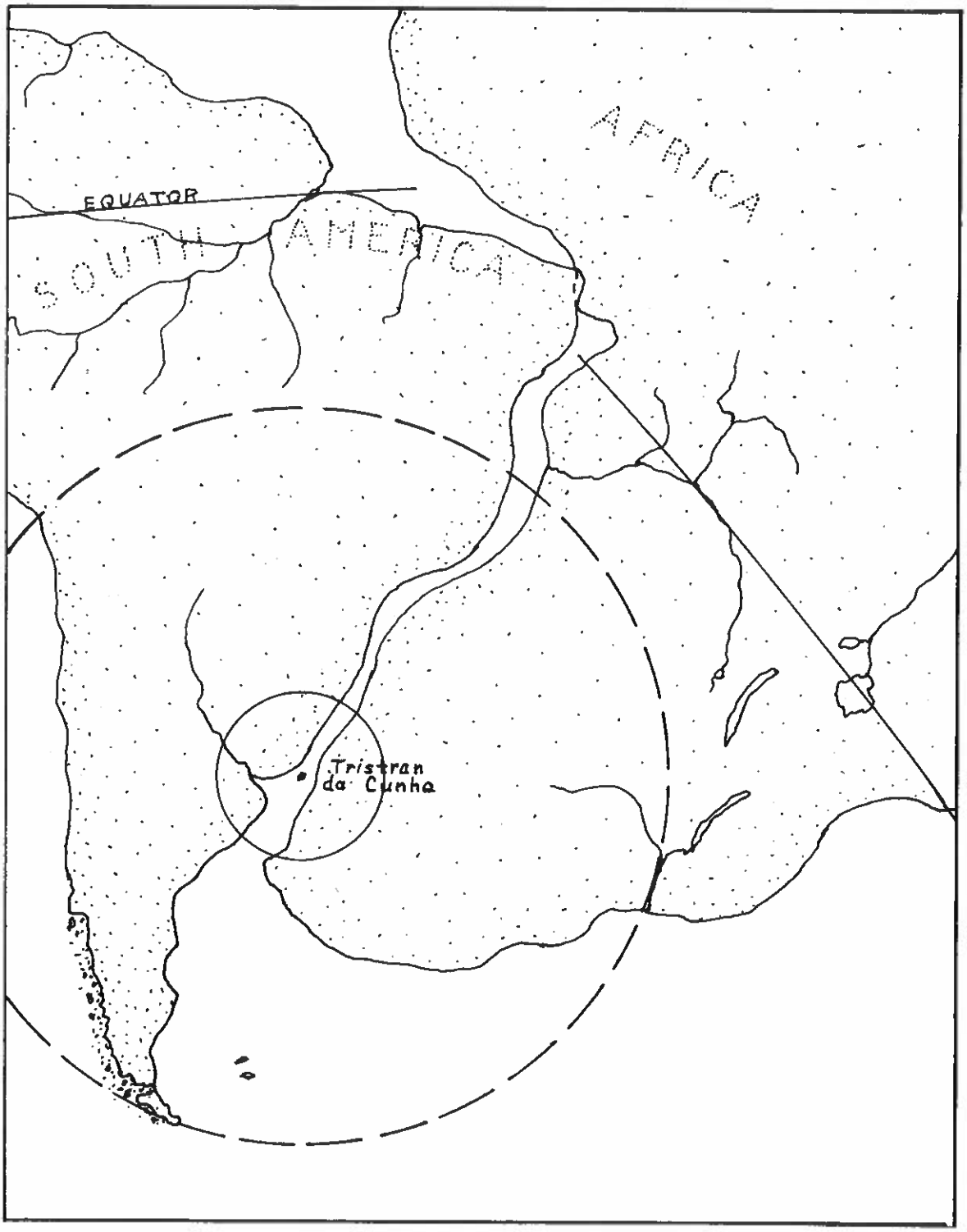


FIG. 18

South America and Africa pushed back to the Mid Atlantic Ridge. The arctic circle is the same size as our present arctic circle and using the island of Tristan da Cunha as the pole, it covers most of the Permian glaciation in South America and Africa.

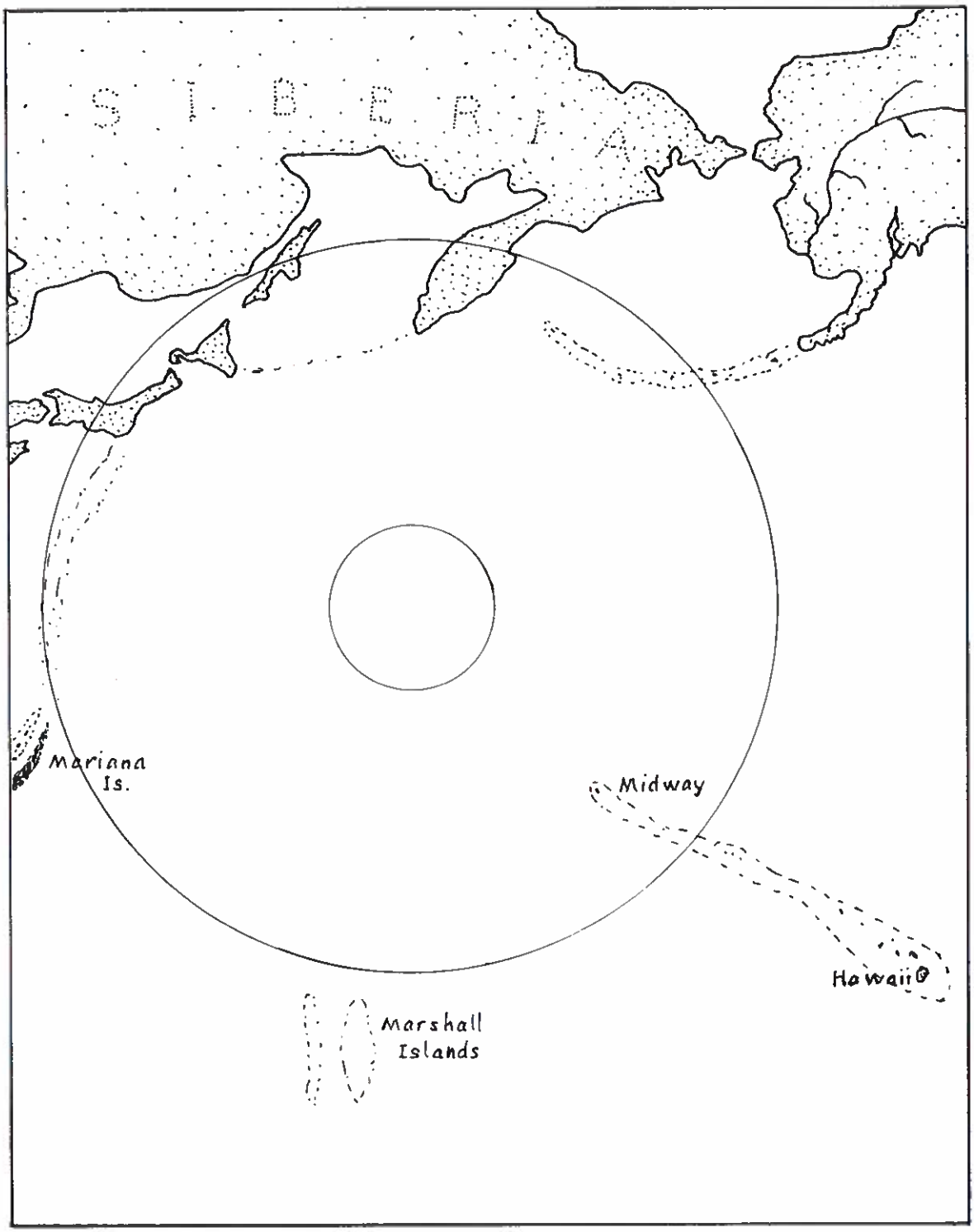


FIG. 19

Permian North Pole and arctic circle as projected through the earth from the Tristan da Cunha pole. It is very unlikely that any Permian glaciation would be found unless on the Kamchatka Peninsula or the island of Hokkaido.

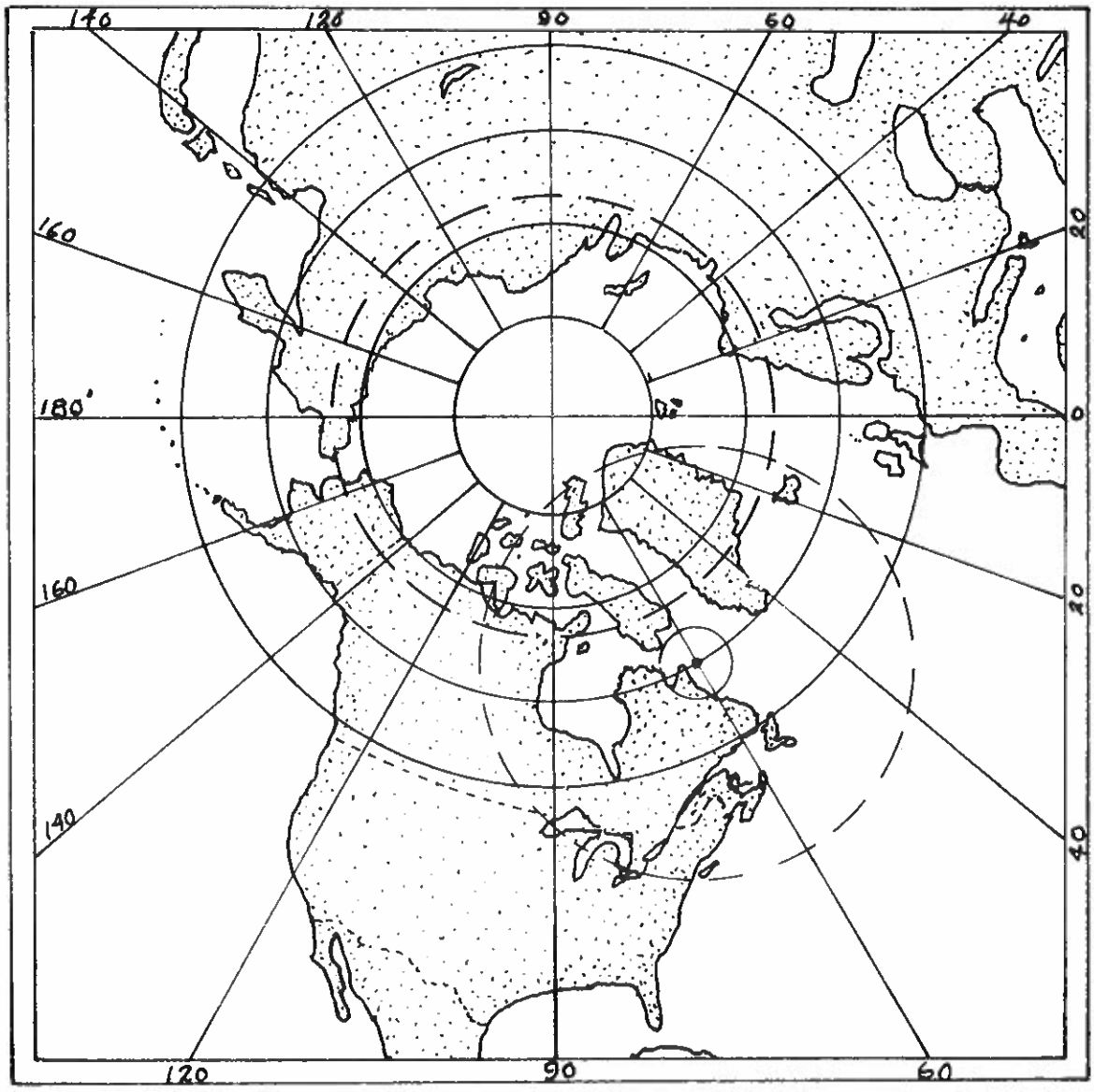


FIG. 20

Map showing old north polar cap centered at 60 degrees north and 60 degrees west as it was probably located in Pleistocene time.

The last great collision which we have postulated as having moved the axis of the earth to its present location, seems to have occurred about 11,400 years ago, judging by carbon 14 age determinations from both the land and the deep sea.

This position of the old polar cap can account for all of the glaciation in the northern hemisphere, from the end of Permian time to the end of Pleistocene time, if we accept massive collision as the basic, dynamic force.

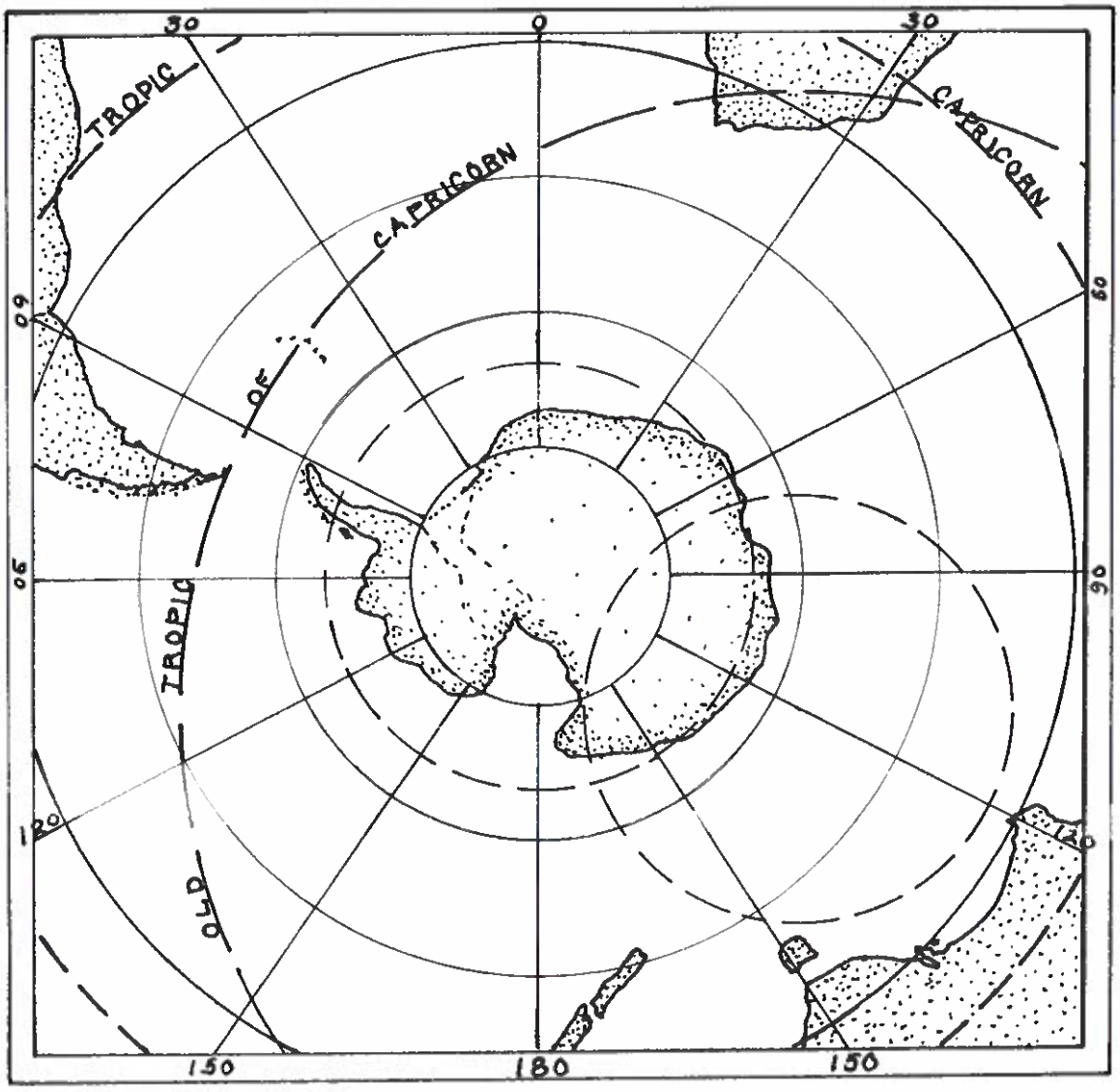


FIG. 21

Map showing old south polar cap centered at 60 degrees south and 120 degrees east as it probably was in Pleistocene time and before the last collision which changed the earth's axis to its present location about 11,400 years B.P. plus or minus 200 years.

It is our thesis that the polar axis of the earth was moved to this location at the end of Permian time when a great cometary collision caused all of the continents to drift and a new rotational axis to form.

The glaciation in the southern hemisphere fits this theory for it will be seen that the old tropic of capricorn passed through the tips of South America and Africa while Australia was close against the old antarctic circle. The south Australian coast was therefore glaciated from the end of Permian time to the end of Pleistocene time. On the other hand, glaciation in Africa and South America came to an end with the Permian collision so that all glaciation there is older. Palmer Peninsula should show traces of this same pre-permian glaciation if it broke away from the tip of South America as we have suggested.

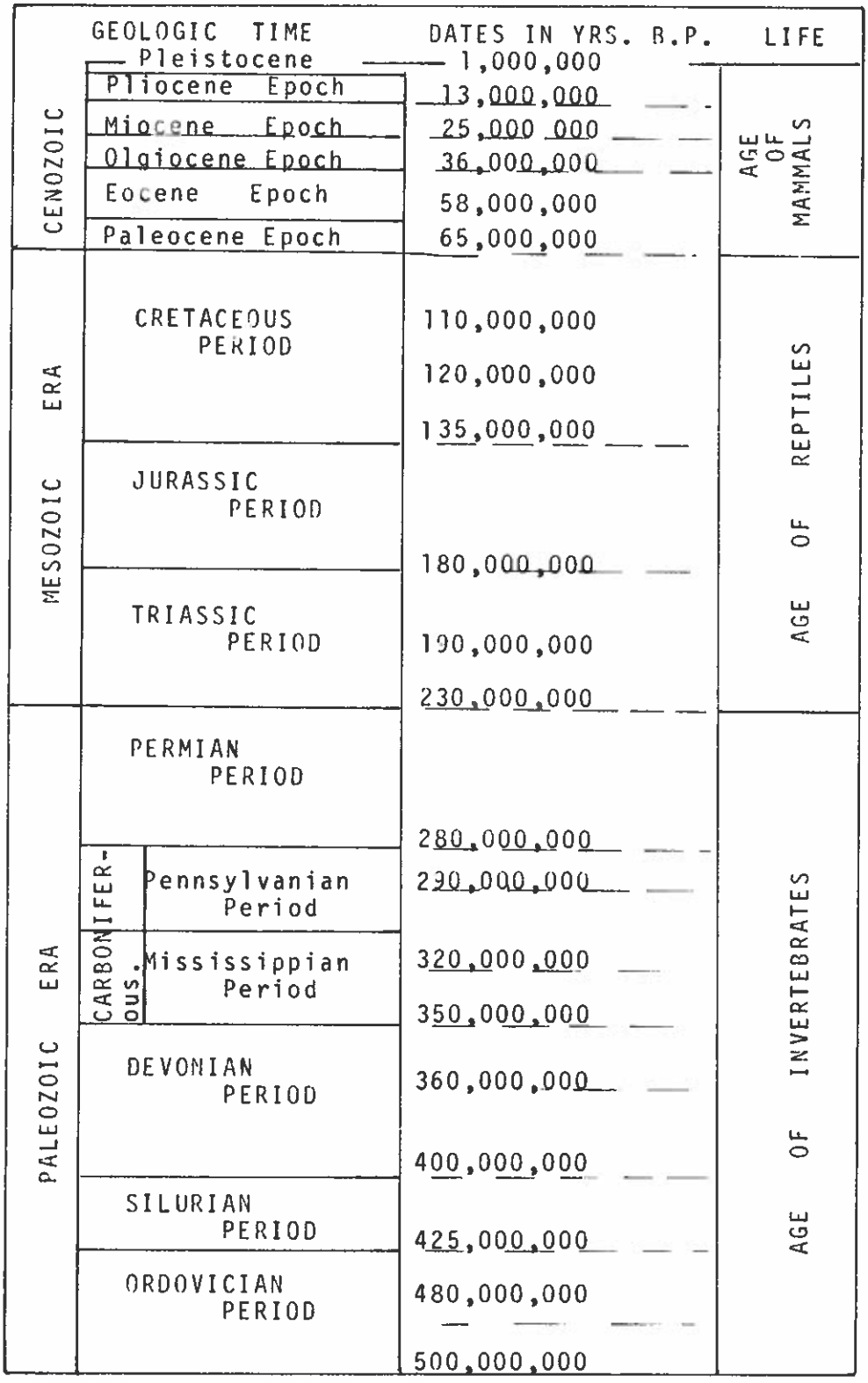


FIG. 22

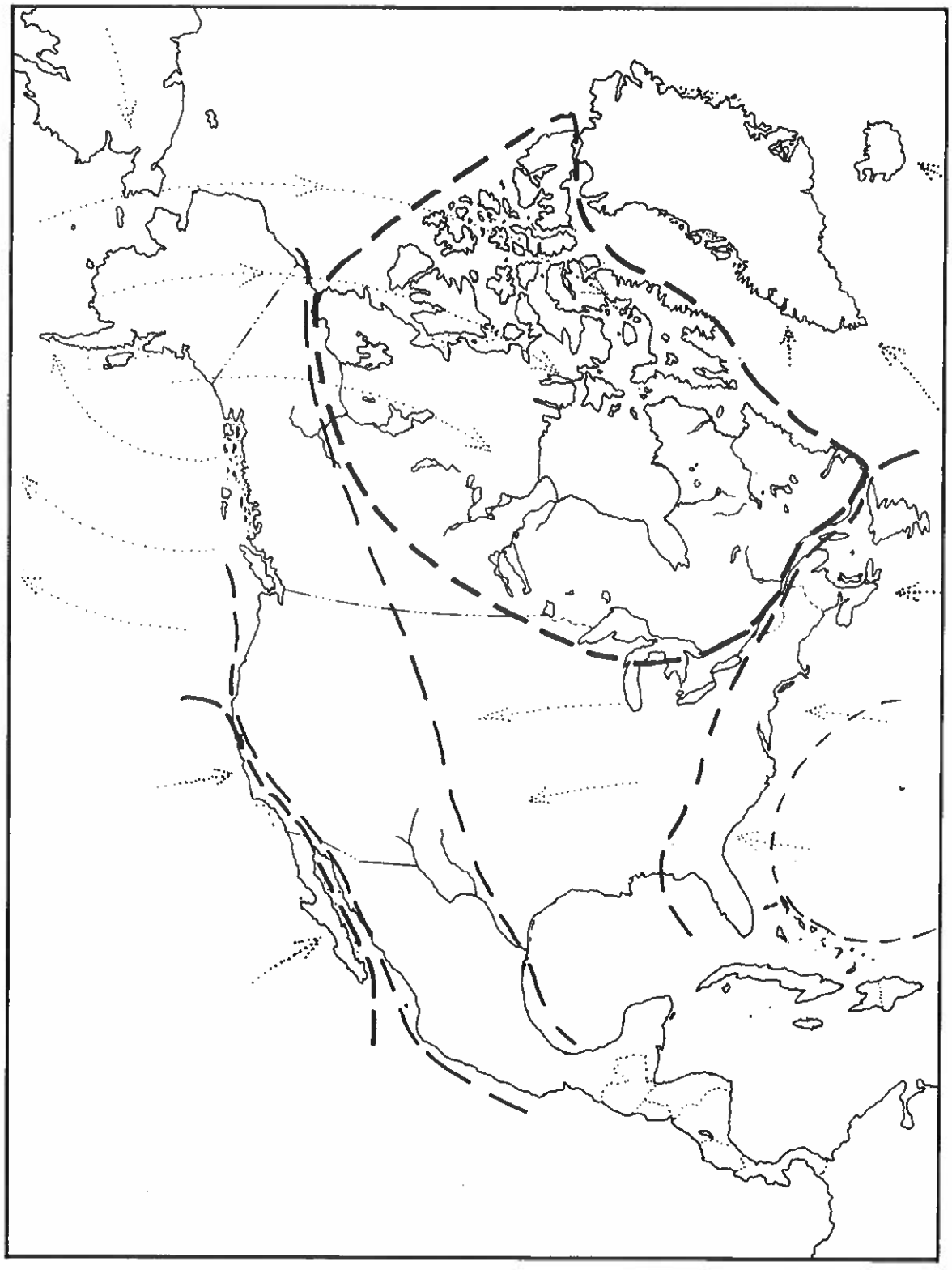
The CAMBRIAN PERIOD began about 600,000,000 years B.P. and the Precambrian extended back to the dim beginning of sedimentation, perhaps 3.5 billion years.

deep Pacific basin. We have proposed above, that everything drifted except the Mid-Atlantic-Ridge but probably these volcanic islands of the Pacific should be excepted, for they were in the middle of the impact area and the product of rebound and later volcanic eruptions. We conclude then, that the large arcuate structures of the far western Pacific indicate that the first strikes were in that region and continued in a southeasterly direction toward what is now the coast of South America. Nearly the whole hemisphere of the earth was subjected to the cometary blast because the physical features indicate this and because the earths 8,000 mile diameter is only one tenth of the average comet head diameter. In this connection it may be significant that one whole hemisphere of the moon is covered with crater-seas (maria) while the other side, recently photographed, shows only one large dark area and it appears to be much battered by later impacts. This would appear to be good evidence that the moon was struck by a comet which made all of the maria at once. Obviously, it couldn't bombard both sides at once.

With the above facts and suppositions in mind, we may begin to consider how each of the continents drifted and why. (See figure 23)

South America and Africa broke apart and drifted in opposite directions, their southern tips moving farther than their central parts because of the spherical nature of the earth. They drifted until they reached an area where lateral pressures from the out-flowing collision lavas, rotational forces, and frictional forces (drag of the crust against the mantle) brought them to a stop. Then followed a back-up or withdrawal of certain portions of the continental masses because their momentum had carried them past the point of true equilibrium. This back-up produced the deep tensional troughs. There are a few minor trends at right angles but except for the Kermadic-Tonga trench and its accompanying features, the general trend of the Pacific Islands and submarine features is from northwest to southeast.

Beginning with North America as perhaps the most complex of the continental-drift masses, we reconstruct its wanderings as follows: First, that it is probably made up of at least three and possibly four separate masses that were partially rotated and pushed together. Of these, the Canadian Shield is the most important and its movement the most speculative, yet we must propose that it was the old north polar cap situated in the North Pacific Ocean as we have outlined earlier. That this mass of glaciated Precambrian rock drifted and rotated slightly in a great arc across the globe to its present location. It was broken up in the process and came to a stop trailing some twenty large islands, now the Canadian arctic islands. The western side of this mass is roughly the Mackenzie River and from there south around through the Great Lakes and up the St. Lawrence River to the Strait of Belle Isle. Newfoundland, Nova Scotia and all of Apalachia down to the Gulf of Mexico came off the Mid Atlantic Ridge. Greenland moved northwest. The Mississippi Valley, which had been below sea level, was raised and pushed against western North America buckling that area into a mass of parallel mountain ridges as it met the pressures coming from the Pacific. California and Baja California, west of the San Andreas fault, was a separate mass which was partially welded again to the main continental mass. Mexico and Central America as far south as Costa Rica were a part of the North American mass and moved back to the northeast pulling a deep tensional trough along the west coast.



FIB. 23

Map of North America showing by dotted line arrows how the various segments may have drifted and finally become welded together.

Alaska and the Aleutian Islands were torn away from the coast of North America, beginning at the Mendocino Escarpment and hinging about a point near Cordova, Alaska. (See National Geographic Globe) These steep mountainous islands along the British Columbia Coast as far south as Puget Sound appear to match the Aleutian Range. The Aleutian Islands with their volcanics match the Pacific Coast ranges as far south as Mount Shasta and the Mendocino Scarp. It is interesting to note that north of the Mendocino Scarp, the continental shelf is some 400 miles wide. It looks as if the Aleutian Islands and Alaskan Peninsula had pulled away from this coast, skidded off the wide platform and hinged around to their present position. Augmenting this speculation, a personal communication from a student at the University of Washington brings the news that recent work there shows that the Olympic Peninsula, Vancouver Island and the San Juan Islands are drifting westward as indicated by the snapping of power cables between San Juan Island and the mainland.

The Aleutian Trench was the final evidence of movement as the lava cooled and the tension is not yet fully relieved as we know from the strong earthquakes and volcanic action that continue there.

The whole Pacific Coast from the tip of Baja California to the Alaskan Gulf held its position and did not back up enough to cause a tensional trough. However, a great deal of cometary material was added to the earth and because of the change of axis and the drifting of continents, a whole new figure of earth equilibrium had to take place. This was partly achieved by long fault zones fanning out from the Pacific Coast. As the Aleutian Arc and the coast of Mexico pulled back and opened their respective trenches, the Mendocino, Murry, Clarion and Clipperton fractures opened and allowed the newly formed ocean floor to raise or lower in the blocks between the fractures, thus adjusting the whole ocean floor to the new configuration of the earth.)see Extension of Northeastern-Pacific Fracture Zones by Menard in SCIENCE, 6 Jan. 1967, pp. 73)

On the southern side of the collision pathway we find only one wide, deep trough, the Tonga-Kormadec Trench, running at right angles to the general island trend. This trench is very deep and nearly 200 miles wide, so that it can hardly be called a fracture zone, although it may have served much the same purpose; one wide trench taking the place of at least five great fractures on the northeastern side of the Pacific Basin.

The continent of South America, having buckled up a long mountain ridge on its western edge as it drifted, came to a stop and then pulled back a little way, leaving a deep oceanic trench along its western coast. In Bolivia, the Andes reach a width of 500 miles. This buckling up of the Andes is a feature noticed by almost everyone who has discussed the possibility of continental drift, but none seem to have advanced the theory that the trench is the result of back-up tension. This trench it will be noticed, follows the coast for some 3300 miles and then at a point about 300 miles below Santiago, Chile, is replaced by a continental shelf covered with a multitude of islands similar to those along the British Columbia Coast and to a lesser degree, those islands along the Adriatic Coast and the Baja California Coast. It appears that this part of the Chilean Coast failed to produce a tensional trough, (perhaps because of less mountain height and weight). In any event, the paralleling ranges split apart with the long ridges breaking up into island

chunks. Palmer Peninsula, which had been a part of the mainland of South America, broke away, and with a part of the group of islands trailing behind it, swung around in a great arc, finally bumping into one of the large islands that is now a part of Antarctica and which was turning slowly in a counter-clock-wise direction. (See figure No. 24) At the same time a section of the Andes (quite narrow in width) broke away under tremendous lava pressures from the west and drifted a distance of about 1500 miles to the east, the while shedding mountainous islands along either side of its pathway. (See figure No. 24) The names of these islands along the south side are, King George Island, Clarence Island, Coronation Island and the South Orkney Islands. To the north, Tierra del Fuego, Cape Horn and a 200 mile long strip of islands were bent around to match the tip of Palmer Peninsula and another string of islands were distributed along the northern side of the pathway. At this point the reader will need a globe or map showing the undersea topography, for these islands are only specks on a wide, curving submarine ridge that seems to have stretched like warm taffy with the South Sandwich Islands forming the end of the loop. Finally, these islands pulled back a little, because of their momentum had carried them too far, and thus pulled the tensional trough on their convex side. (See figure No. 24) This drifted feature is shown so clearly on a good globe that one wonders how it would be possible to explain in any other rational manner.

Apparently the southern Andes were not high enough or heavy enough to sink into the mantle and thus pull a tensional trough. Instead, they were broken in the canyons between ridges and these ridges sheared off and moved across the continental platform, for they had just been buckled up by lateral drift and were easily moved. Palmer Peninsula, the most western ridge of this mass, broke away with its share of islands anchored in the half-melted basement rocks, turning half way around as it drifted to the south. The length of Palmer Peninsula and its satellite islands fit well into the South Chilean Coast and if the fossil remains and rock types match, this will be strong evidence of continental drifting. (See figure Nos. 24, 25) If future field investigation proves that these vast island masses did move or drift, as above depicted, and if collision is not the motive power, then how shall we arrange the convection cells within the earth to have accomplished these movements?

As is now well known from Antarctic exploration and seismic traverses of the south polar cap, the Ross Sea and Weddell Sea are joined by a channel below sea level which is filled with glacial ice, but so little geophysical work has been done that the actual outlines of these ice-covered islands is still largely unknown.

New Zealand is something of a mystery too. Its mountains are too young to be a part of Australia and its coast lines do not appear to fit anywhere against Australia. However, there is the possibility that the mountains of South Island fit against the mountains of Victoria Land bordering the Ross Sea. The undersea features such as the South Auckland Rise and the New Zealand plateau, which stretch away toward Victoria Land, would seem to give some credence to the idea. (See National Geographic Globe)

Australia appears to have drifted to the northeast, possibly a thousand miles, judging by the width of the deep basin behind it called the Great Australian Bight. Tasmania seems to have

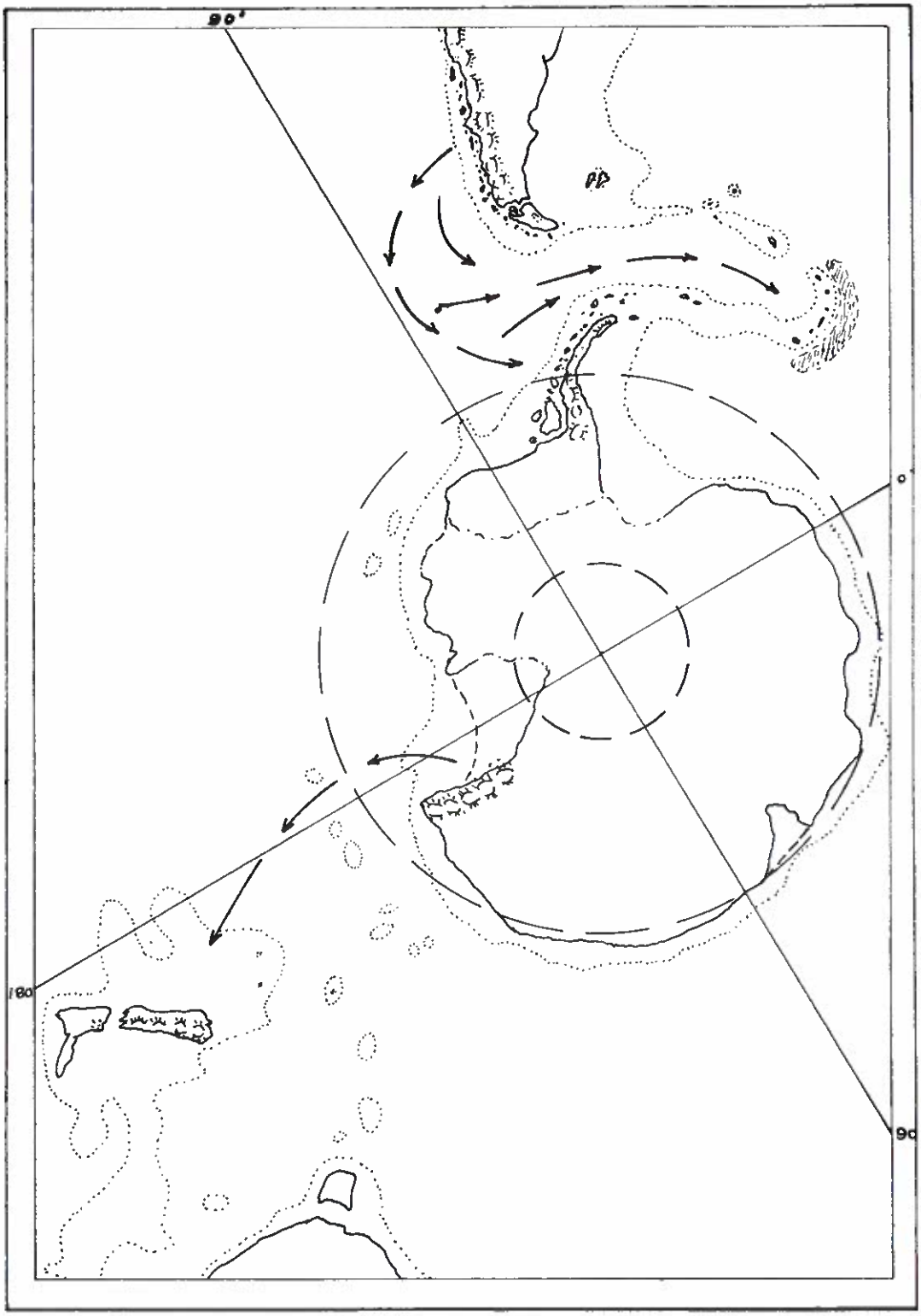


FIG. 24
Antarctica and adjacent areas showing possible drift of South Sandwich Islands, Palmer Peninsula and possibly, New Zealand. (After National Geographic Society Globe.)

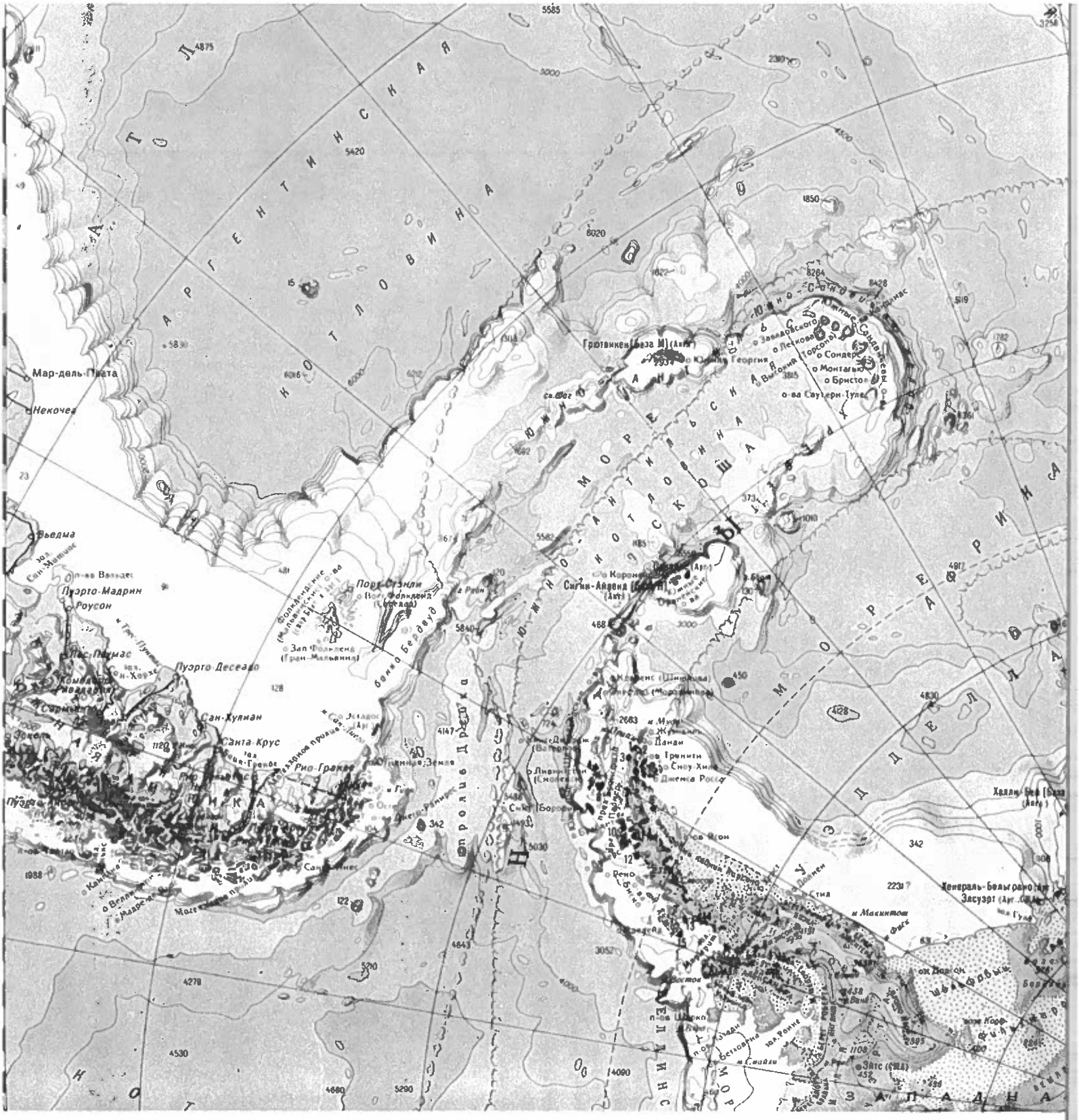


FIG. 24A

Map showing in greater detail, the wide, deep channel, left behind the South Sandwich Islands as they drifted to the east following the break-up of the South Chilean Coast as Palmer Peninsula broke away in a great turning movement. The deep South Sandwich Trench was formed as these islands pulled back a little way.

Credit note: This map is a portion of the map on pages 16-17 of the new Soviet Union Atlas of Antarctica as produced from the combined data made available by the several countries taking part in the exploration of Antarctica during the International Geophysical Year of 1958.

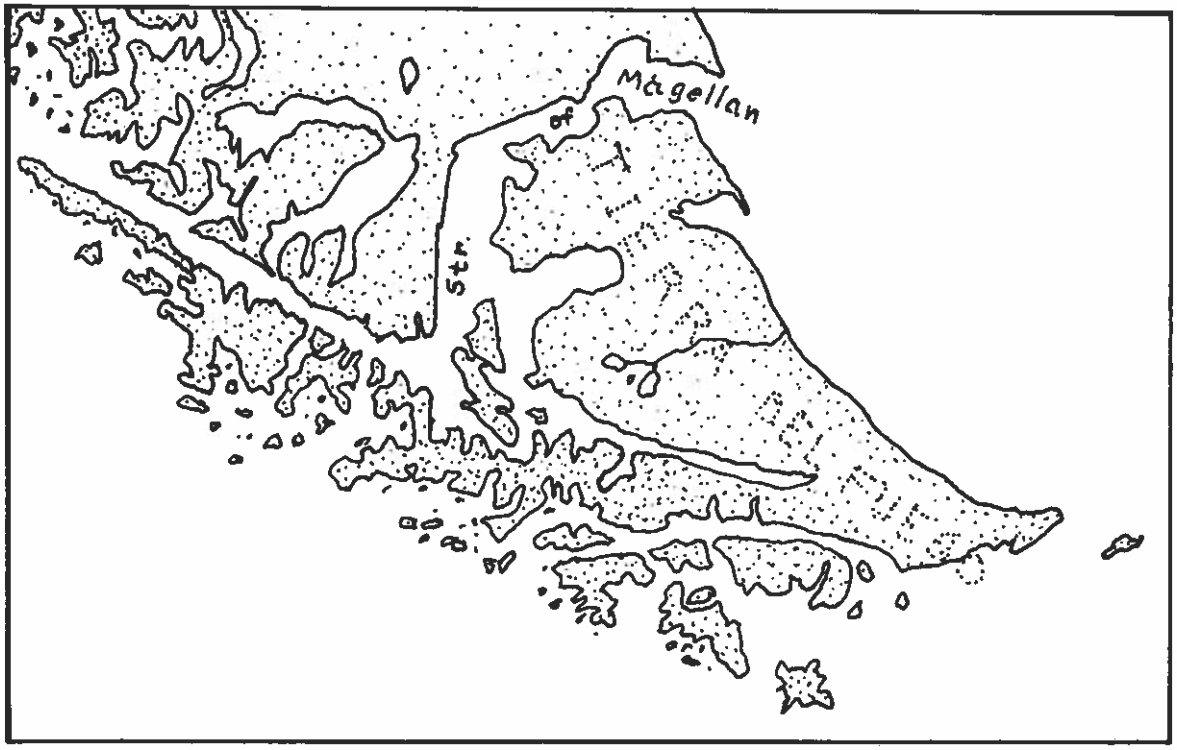


FIG. 25

Map of tip of South America showing parallel faulting along the axis of the Andes and the multitude of "drifted" islands including Tierra del Fuego. These broken chunks of mountains are due to the Permian collision and should contain the remnants of a broken up peneplane of glaciation that has been tilted in different directions, by collision-drift.

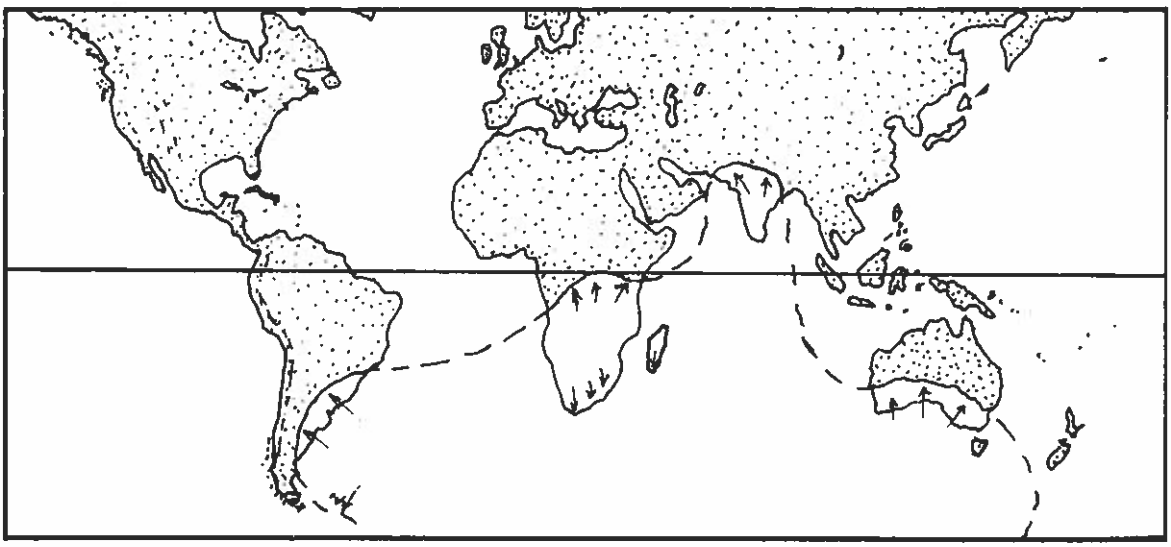


FIG. 26

World map showing glaciation in the southern hemisphere in Carboniferous Time, according to Holmes, 1944. The directional movement of ice (arrows) has led various students of continental drift to agree that all of these glaciated areas were once joined together to form "Gondwanaland." From field observation in both Africa and Australia, I think that the African glaciation is Permian. Australia may have been glaciated in Permian time but the glaciation in southwestern Australia is far to fresh to be older than Pleistocene as is also the glaciation in the South Island, New Zealand.

broken away from the south coast of Australia, falling behind somewhat in the drifting and New Guinea, being on the collision side, was wrenched loose from the northeast coast of Australia and swung around some 45 degrees to its present location. See figure No. 27)

The Sunda Arc is the next great collision feature on the south side of the Pacific Basin. This is the largest arcuate structure on the face of the earth and probably the most complicated, if we include the islands inside its basin. The Sunda Arc stretches from the Andaman Islands at the northwest end of the arc, all the way to the island of Timor, a distance of nearly 3,700 miles. It is bounded on the south through most of its length with a deep oceanic trench. Beyond the trench is the Wharton Basin, deepest area of the Indian Ocean, having a depth in excess of 18,000 feet over an area of more than 500,000 square miles. The tensional trough along the eastern end of this arc indicates a drift to the north by Sumatra, Java, Timor and the lesser islands of the chain. This appears to have been the southern section of a gigantic crater made by one of the largest projectiles in the cometary train.

The combined shocks of so many gigantic bodies in quick succession, caused all of the continental masses to break up and to drift toward the Pacific hemisphere of the earth. Asia moved toward the east, pushing and squeezing all of the large, first made craters out of shape. The island of Borneo was split off the South China Coast and drifted into the center of the Suna crater basin. On the northeast side of this basin, the Philippine Islands drifted southeast, pulling a trough more than 1,000 miles long and one of the deepest in the world. The Celebes and the Halmahera Islands appear to have pulled out of the eastern rim of the crater and moved west; the waving arms and octupus-like form of the Celebes give the impression that long chunks of crater rim were pulled away, twisted and turned and then welded together again in a new and grotesque form. If this seems a bit fantastic, try to explain them in detail by conventional geologic methods. (See figure Nos. 27, 28)

By using cut-outs of large scale maps of this area, Borneo may be fitted back into the South China Coast along with the islands of Taiwan, Luzon and Hinan, but the whole of southeast Asia must be pushed back to make this great crater basin into a circle again. (See figure Nos. 27, 28)

Another interesting fact about this basin is that all of the water area around Borneo shows high gravity anomalies, indicating very heavy basic lavas in this basin upon which the islands could drift. F. A. V. Meinesz carried out gravity surveys in this area in 1933 and 1939.

Farther north along the coast of Asia we see the distorted remains of other large impact scars mentioned earlier. These are: The East China Sea, Sea of Japan, Sea of Okhotsk and probably the Bering Sea. All of these were apparently once nearly round as indicated by the deep earthquake patterns. This is a fact of great importance and one difficult if not impossible to explain by any other reasoning. (See Seismicity of the Earth, Gutenberg & Richter, pp. 55-56) For example, the deep shocks under the Sea of Japan (those with a focus below 300 km) extend entirely across the basin and under the mainland of Asia. This would seem to mean that the crust of the earth drifted over the western part of this basin of hot magma, forming a sort of lid over this ancient kettle. It is probably still molten hot deep down, hotter than the surrounding man-

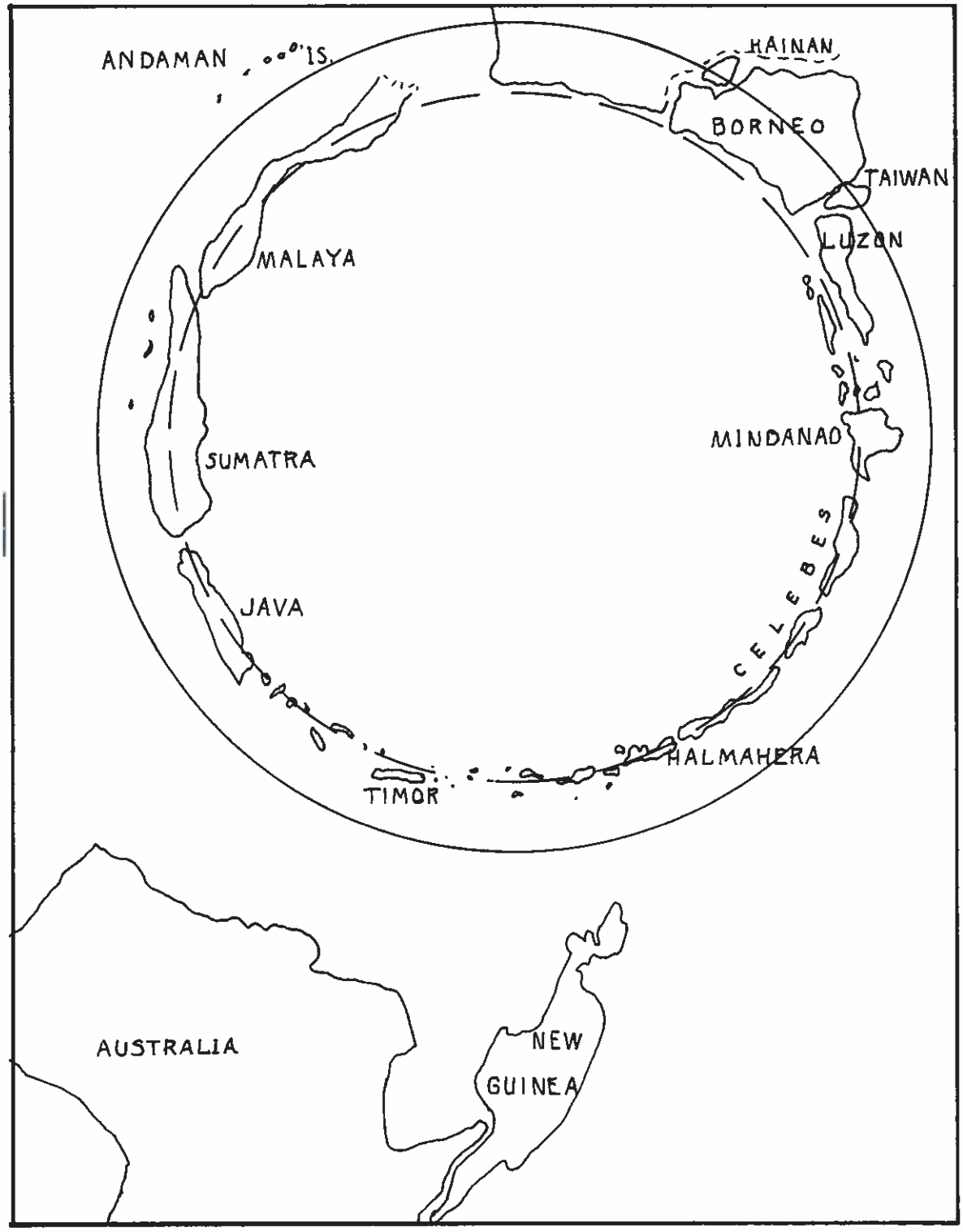


FIG. 27

The author's conception of how the Sunda Arc appeared immediately after the cometary collision and how the continents and large island masses drifted from former locations.

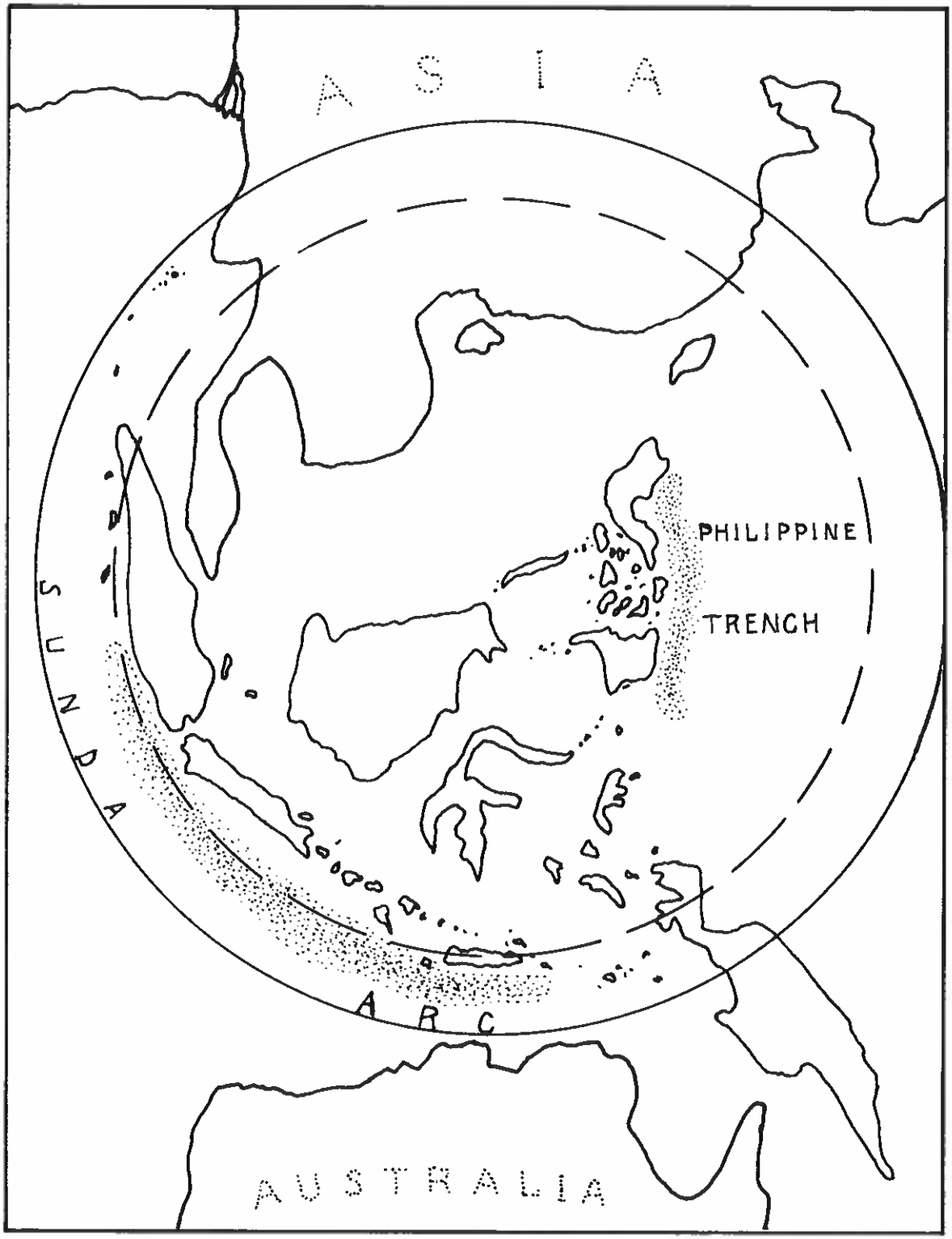


FIG. 28

The Sunda Arc and Southeast Pacific area showing the islands and continental masses as traced from a 12 inch National Geographic Globe.

tle, so that as this heat is slowly dissipated into the rocks of the cooler mantle, a slow shrinking takes place and finally a sudden shock as the earth's crust lets down a few inches. The deep focus earthquakes probably outline the bottom of the lava pool and the shallower shocks follow up the sloping sides of the pool. Thus all of the earthquakes in and around such a crater bowl and those on the inside of the accompanying tensional trough can be explained by this method. The near total lack of earthquakes outside these bowls and beyond the oceanic trench, proves our point. (See TARGET: EARTH, pp, 99-101) (See figure No. 29)

One of the more unusual structures in the western Pacific is the Mariana Arc and its accompanying trench. This is the deepest such tensional trough in the world having a maximum depth of 36,198 feet. The Mariana Arc was probably made in an already deep ocean basin or in molten magma already developed by the cometary train and therefore it penetrated more deeply and left two accompanying arcs instead of one. The result was two arcs nearly 1,000 miles long and separated by some 250 miles of deeper ocean. These undersea ridges are covered by some 9,000 feet of water and the outer one is outlined by a string of island volcanos known as the Marianas Islands. Guam is the largest and best known of these islands. (See figure 30)

The Hawaiian Islands are the most important feature in the northern section of the Pacific Basin. These islands are oriented in a northwest southeast direction and extend in a nearly straight line for over 2,000 miles. All signs of individual collision craters are lacking and there are no arcuate structures or accompanying trenches. If there was any pre-collision land mass in this area, it has completely disappeared.

The Hawaiin Islands, except for the big island of Hawaii, are nearly lacking in true volcanoes but are entirely made of lava. They have more the appearance of rebound peaks and when one considers how high and steep these island mountains are, rising off the floor of the deep ocean, there must be a reason other than ordinary vulcanism. The tiny craters on the island of Oahu, like Diamond Head and the Punchbowl, did not produce the long, high, mountain ridge that is more than twice as high as these craters. (See figure No. 31) Another characteristic of these islands is the near vertical cliffs known as Pali. They have been eroded into chimneys and intervening columns that have little resemblence to the typical volcanic island built up by volcanic flows. (See photo No. 12) Most of the other islands, excepting the big island of Hawaii, show this ridge and pali topography. (See figure No. 32)

The island of Maui, next in line to the big island of Hawaii, is an intermediate type. It has over-steep slopes for a shield volcano and a ridge topography that ends in the great caldera of Haleakala whose rim is about 10,000 feet above sea level. This huge caldera, could be a slump feature in the top of a rebound peak and at the same time, show active vulcanism such as the emission of smoke and steam. In any event, there is strong evidence that the whole Hawaiian chain is a product of multiple blast in which a number of striking bodies followed each other in a line, striking in quick succession. A feature supporting the collision hypothesis is the moat and arch topography surrounding this chain. (See Marine Geology of the Pacific, Menard, pp 79-81) Recent echo sounding surveys of considerable detail show that a moat or depression surrounds the islands close in to shore and that this is encircled by a tremendous arch whose

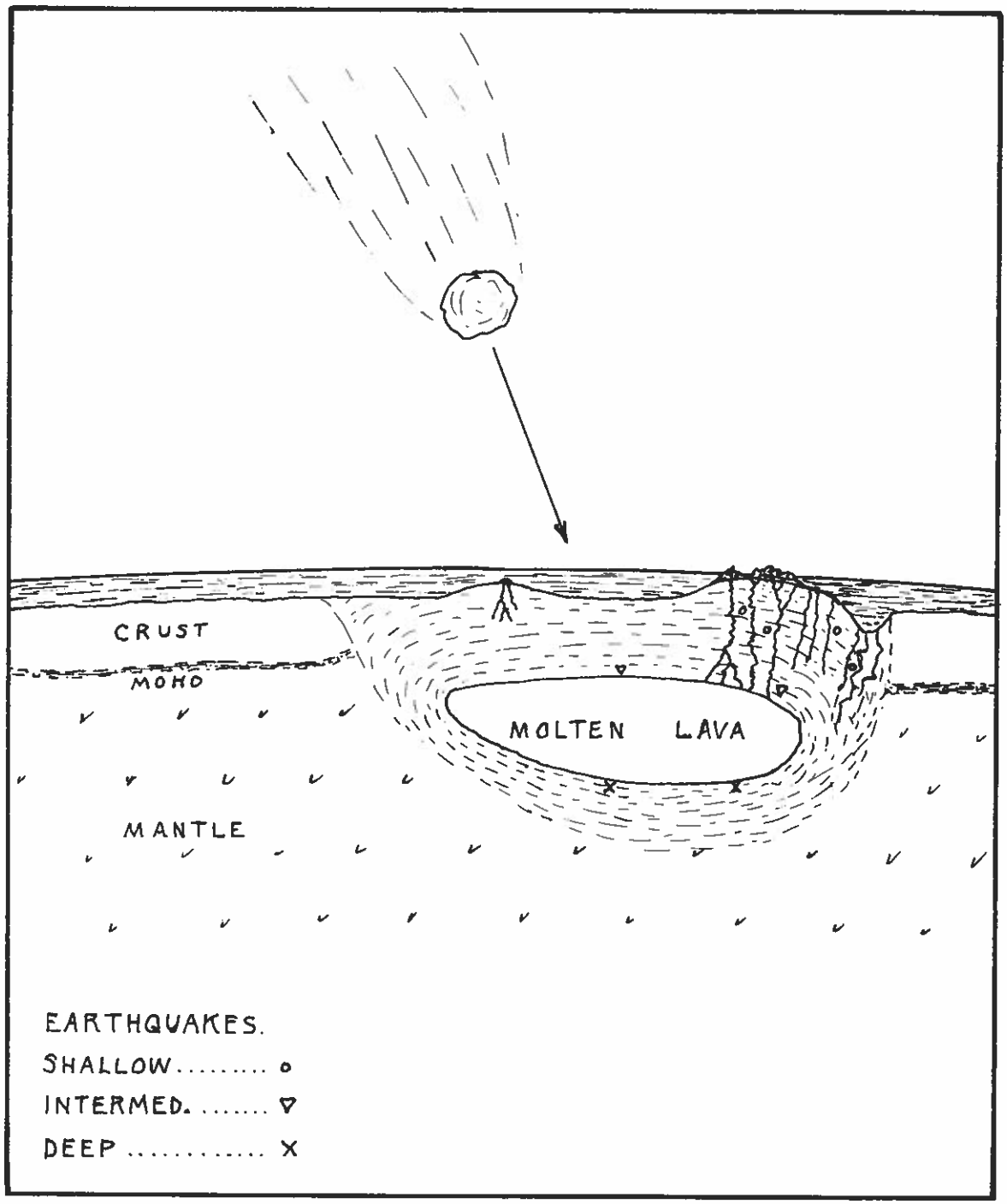


FIG. 29

Cross-sectional view of an island arc illustrating how an oceanic trench may be formed outside of the arc by partial drifting of the crater rim. Also, how volcanoes may migrate toward the inside of the arc as lava pool shrinks in size over millions of years in cooling and why the earthquakes occur as deep, intermediate and shallow shocks.

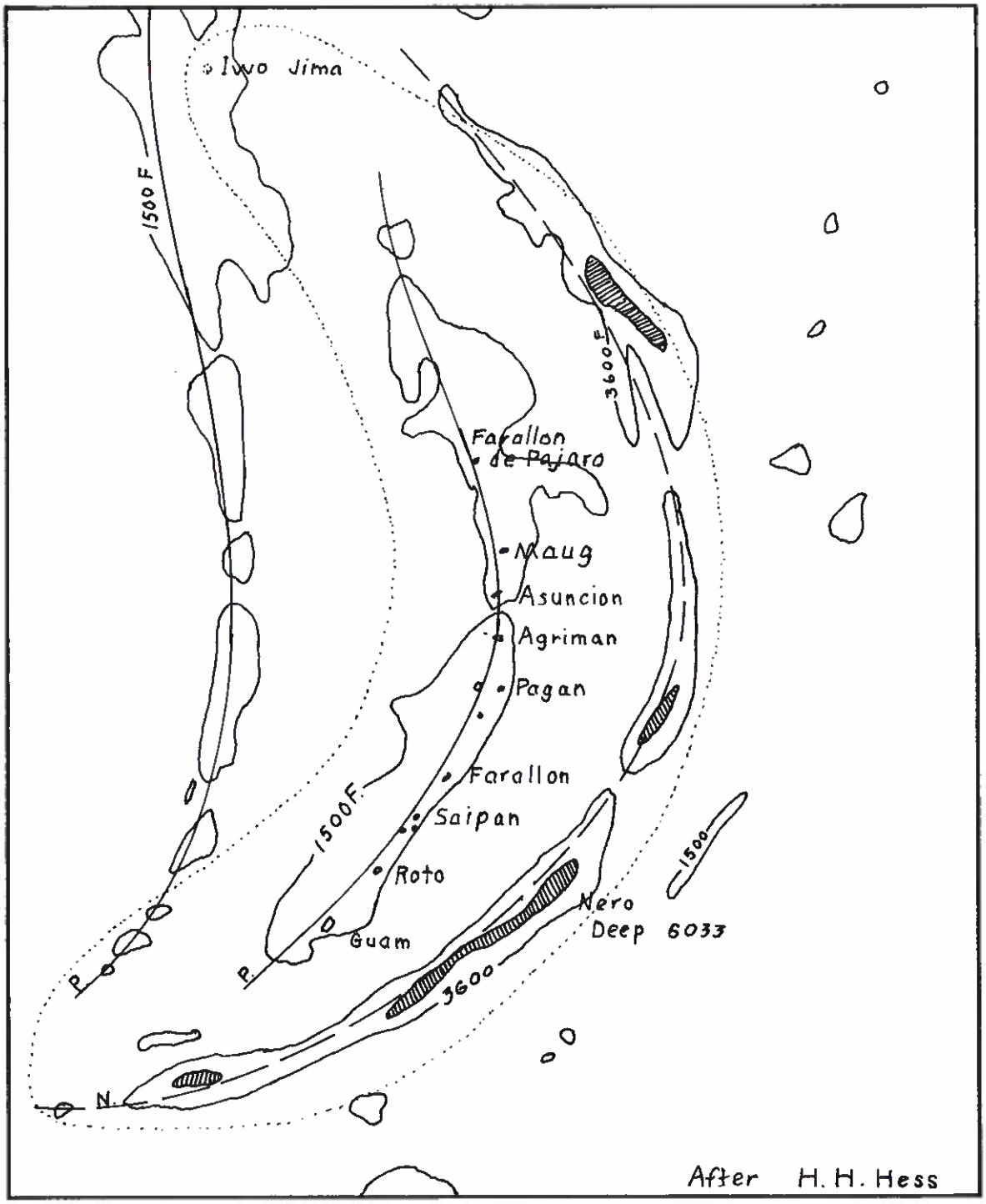


FIG. 30

The Marianas Island Arc showing positive and negative gravity anomalies and the secondary arc on the concave or western side. All depths in fathoms. The fine dotted line indicates the boundary of the zone in which earthquakes have been recorded.

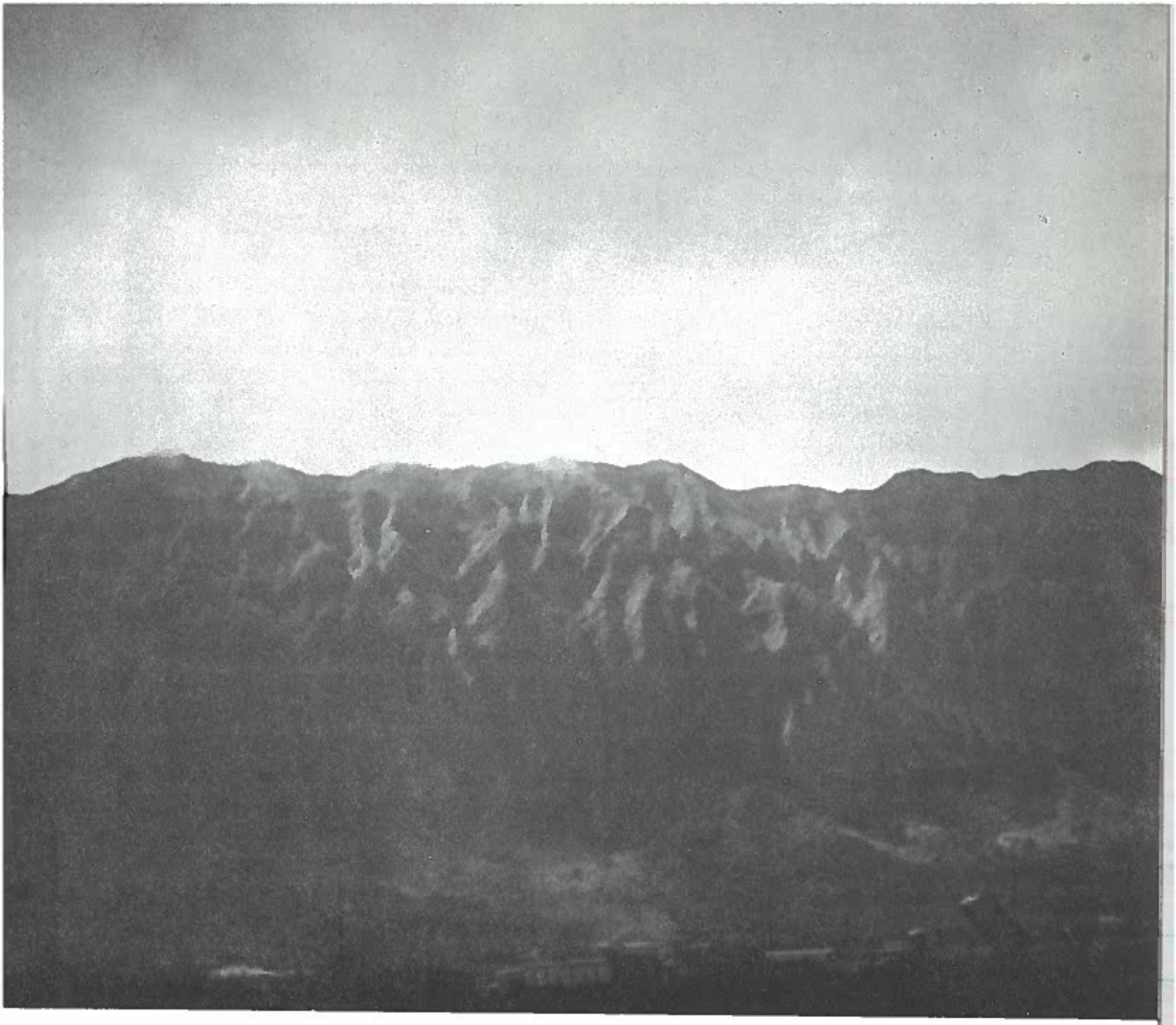


PHOTO NO. 12

Long lava cliffs known in the islands as Pali, Island of Oahu. This long, nearly level ridge is about 1,500 feet high with fluited cliffs on the near side and more gentle slopes on the other. The lava is found lying in thinly layered beds that have little resemblance to typical volcanic lava flows.

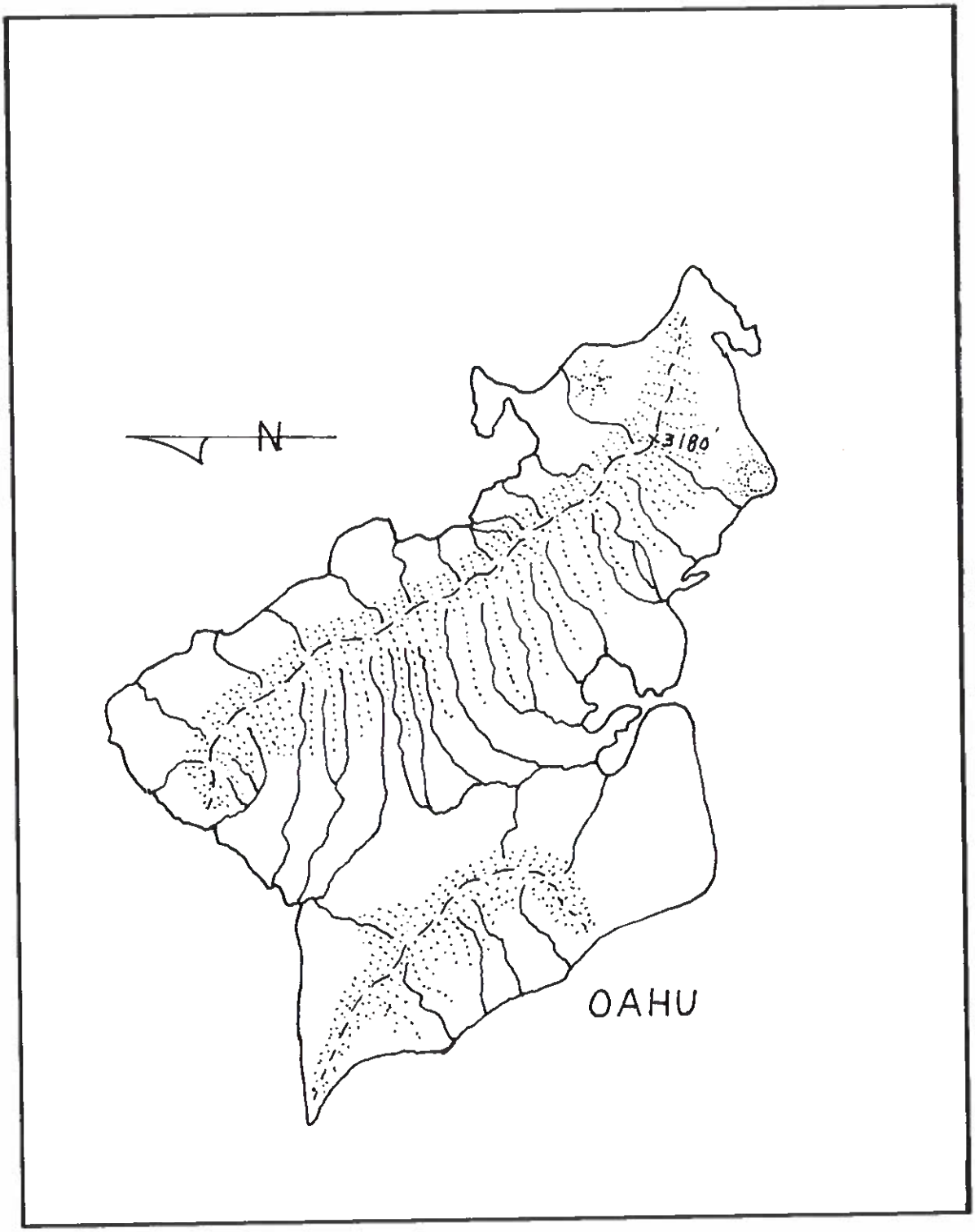


FIG. 31

The island of Oahu showing in detail the high lava ridges and stream pattern. The two tiny craters are less than one third the height of the main mountain ridge, proving that they did not build the ridge.

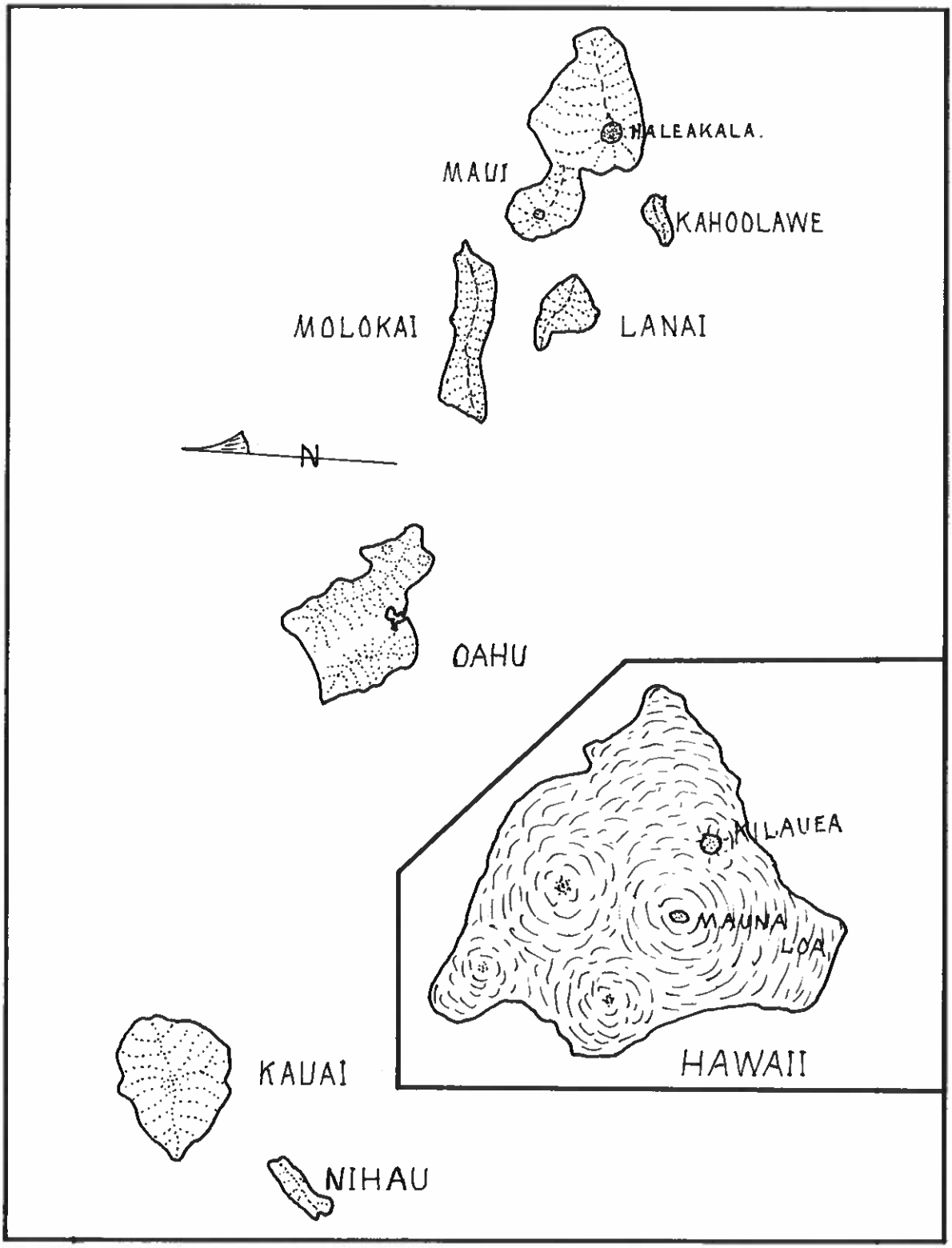


FIG. 32

Map of the Hawaiian Islands showing that all but the main island are elongated mountain ridges, not conical volcanic peaks. The insert of the Island of Hawaii shows the true volcanic peak with radiating lava flows.

crest parallels the moat at a distance of about 125 miles (180 km) outside the moat. The total width of this arch from the deepest part of the moat to the outer limit of the arch is about 250 miles. This seems to be a feature common to these undersea mountain ranges including many whose peaks do not break the surface of the ocean, and it would appear that it supports collision much more than it supports vulcanism. We would say that this would be the natural result of collision and rebound. It represents the first giant ripple moving out from the center of impact. If we drop a stone in the water, a primary ripple or wave moves out followed by a trough and a rebound peak at the center of impact. In a liquid as thin as water, many more waves are formed, radiating outward, but in a more viscous lava, only one wave or arch was formed and the impact peaks rebounded and then settled somewhat. On the other hand if the ocean floor had been lowered into a surrounding moat by the eruption of lava into high mountain peaks, no paralleling arch would have been formed. Of course, we see no reason at all why a chain of submarine volcanoes should develop in the deep ocean so far from higher continental masses that might conceivably, generate isostatic pressures in the mantle to raise such lava mountains. In other words, there must be a first cause for the vast expanse of the deep Pacific floor and its heavy magmas. The true volcanoes are only a speck of this mass or area, although Menard says that there are at least 10,000 volcanoes on the bed of the Pacific Ocean. The vast amjority of these, of course, are merely peaks and flat topped guyots that are taken to be volcanoes because the dredge brings up lava from their surfaces. According to Menard, many of them have been found to be capped with water worn gravels that could only have originated on a shore line. He further points out that water-worn volcanic pebbles have been dredged up from the crest of the Mendocino Escarpment and he takes this to mean that the pebbles were made there when the area was above sea level and *not* that they were rafted there by ice. We agree with this observation.

From our point of vieew, it would appear logical to suppose that much of the Pacific hemisphere of the earth was land surface and that parts of this area survived actual impact, and that these areas and thousands of rebound peaks subsided after the collision and were left below sea level when the earth finally reached a new equilibrium.

Another physical fact supporting our thesis of collision and of directional trends is that the great fracture zones fanning out from the Pacific Coast do not have volcanoes along their axes as one might expect nor do they have rebound peaks. On the otherhand, the Guyots and supposed volcanic peaks are found scattered over the deep ocean floor between the fractures. (See Marine Geology of the Pacific, Menard, pp 77) The long chains of islands that we consider rebound peaks follow a trend nearly at right angles to the fracture zones and they contain all of the true volcanoes and slump calderas.

In a recent report published in SCIENCE, 29 July, 1966 called Molokai Fracture Zone: Continuation West of the Hawaiian Ridge, by Malahoff, Strange and Wollard, of Hawaii Institute of Geophysics, it is shown that the Molokain Fracture Zone passes directly under the islands from east to west and then bends to the southwest. This would indicate that the fracture zone developed after the collision and that it had nothing to do with the formation of the islands or the volcanics of the main island of Hawaii.

The island of Hawaii with its dominating shield volcanoes has been called the "safety valve" of the Pacific. This is probably true in a certain sense but it might better be called the adjustment vent of the Pacific. The great arch surrounding the moat described above is probably exerting an isostatic pressure that is being gradually relieved by the outflow of lava through this vent. The nearest volcanoes to this vent are the dormant ones in California and Oregon and those in the Aleutian chain, which are more active but about the same distance, 2400 miles. In all other directions, active volcanoes are much farther away.

It is well known too, that the floor of the ocean over this vast basin is very stable and free from seismic disturbance. Only six class "C" earthquakes have been recorded in the vicinity of the Hawaiian Islands and they were all shallow and associated with volcanic eruptions. This indicates, as mentioned earlier, that practically all stresses in this vast basin were relieved after the cometary collision because of uniform melting and cooling. The fracture zones, soon after collision, further relieved the tensions and compression in the Eastern Pacific Basin.

Examination of some of the first echograms showed that the floor of the ocean near most of the great volcanic groups like the Hawaiian chain, was unusually smooth (Dietz & Menard, 1953) Menard supposes that this was caused by the outflow of very thin lavas near the base of these volcanoes and he gives them a name, "Archipelagic Aprons." The absence of the usual "abyssal hills" he thinks has resulted from these thin lavas overflowing the hills. In our opinion this smooth floor in the moat area around the islands indicates a tensional pull while the magma was still hot and the rebound peaks were slowly settling. This is further proved by the fact that the smooth slope continues up to the top of the arch surrounding the moat. It is not very likely that thin lavas coming from the base of these islands would flow down across the moat and up to the top of the arch beyond, a distance of over 100 miles and an up-grade distance of about 2500 feet.

What some oceanographers and marine geologists overlook is that the weight of the water exerts tremendous and uniform pressure on these deep submarine slopes and therefore prevents discharges at the base. It is plain that the lava has moved toward the point of least resistance and that has been up through the center of these rebound peaks. It is not likely that a new volcano would break out on the floor of the deep ocean and if it did, that it would do anything but spread out and fill the depressions.

We could go on at much greater length, discussing the geological anomalies having to do with continental drift and the collision theory, but this should suffice to show that collision geology can usually offer a logical solution where orthodox theory runs into a blank wall.

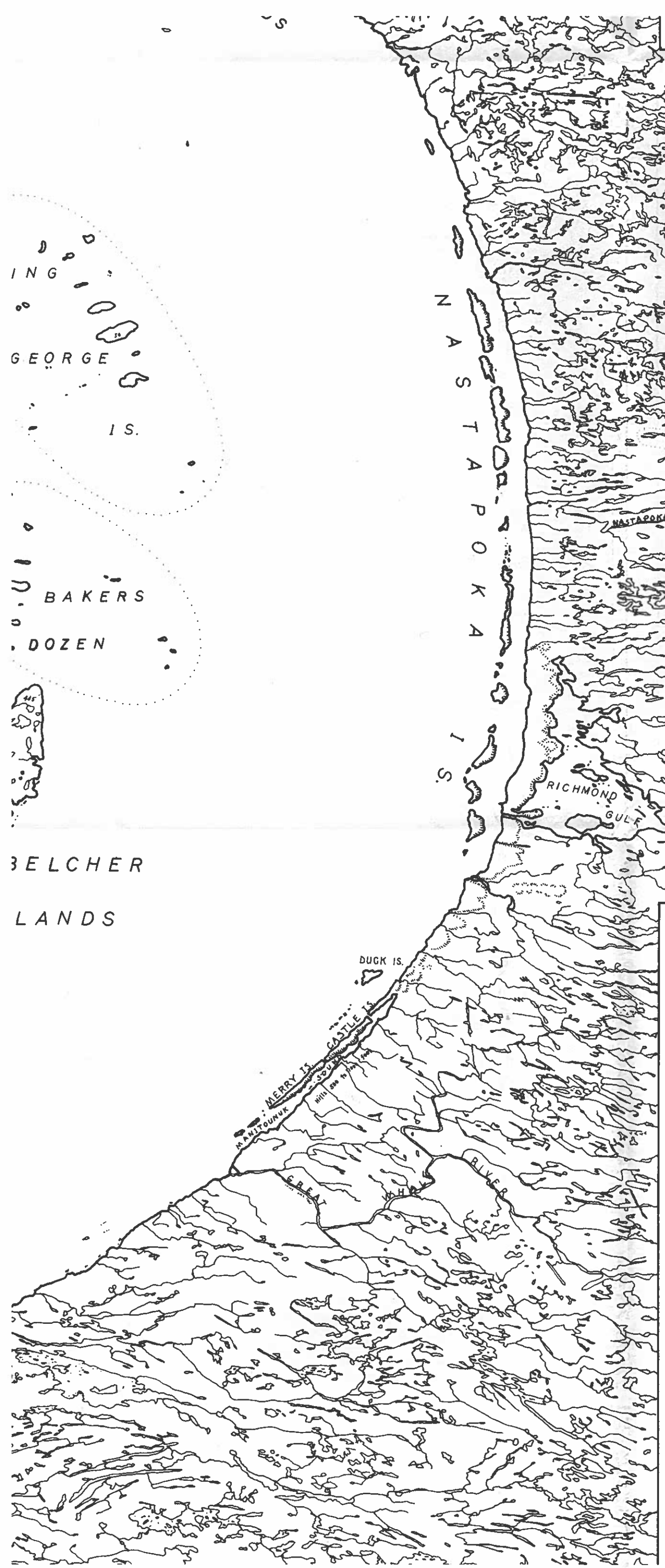
In summary: The basic premise of collision geology is that the earth is a part of the solar family, including the asteroids and comets; that earth history cannot be separated from the history of the rest of the solar family and that collision with asteroids and comets has been the dynamic force in shaping the earth.

To compare principles: Orthodox geology maintains that present day earth forces are the keys to understanding earth features made in the past.

Collision geology holds that the physical features of the earth are the keys to understand-

ing the forces that made them.

To end on a philosophical note: It is the writer's experience that an innovator in the field of geology, (or any other field) needs plenty of determination and a strong belief in his own powers of reason. He needs to do constant reading to keep up with the great body of current literature, both in geology and astronomy and the other fields of Natural History, so that he may learn of anomalies and new facts and features being constantly discovered by others. As a field geologist he must train himself to look for the anomalies, for the unusual and un-natural aspects of the landscape and to think each problem through. He needs to be a close observer of all the facets of Nature and to do this he needs to go-it-alone, to avoid the distractions of other people. One cannot acquire this talent of close observation in the laboratory or in the classroom any more than one can become a proficient chemist by wandering through the woods or over the mountains. This is a fact often overlooked by both instructors and students who sometimes imagine that a few field trips while in college and a summer or two in mapping some geologically interesting land forms, will somehow make a sharp and proficient field geologist. In this connection, John Constable has been quoted as saying: "The art of seeing Nature is a thing almost as much to be acquired as the art of reading Egyptian hieroglyphics."



THE HUDSON BAY ARC

A TRACING FROM FOUR SHEETS OF THE NATIONAL TOPOGRAPHIC SERIES MAPS, DEPT. OF MINES AND TECHNICAL SURVEYS, OTTAWA, CANADA.

MERCATOR PROJECTION

SCALE
16 MILES TO 1 INCH

OTTAWA IS.

ELSIE IS.

HOPEWELL ISLANDS

KING GEORGE IS.

BAKERS DOZEN

BELCHER

NASTAPOKA IS.

RICHMOND GULF

Mount Wilson and Palomar Observatories

48 NGC 7293 Planetary nebula in *Aquarius*. Photographed in red light. 200-inch photograph.