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Ocean Survey Program (OSP) Bathymetry History : Jousting with Tectonic windmills

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Abstract: The plate-tectonic hypothesis in the ocean basins is difficult to defend. The hypothesis was formulated in the early 1960s when relatively little was known about the ocean floor, roughly 70% of Earth's surface, and ocean floor mapping technology was still in its infancy. A small scattering of ship-of-opportunity sonar data did little to show anything other than a few megatrends, such as fracture zones and mid-ocean ridges. In 1974 an updated bathymetry set became available for the general public, but it was not incorporated into the working hypotheses. It showed, especially for the Pacific basin, trends going WSW--ENE, and trends going NNW--SSE. The data also showed mini-crosstrends passing WNW--ESE. These were result of hot-spot activity and were used to show seafloor spreading to the WNW. From 1967 to 1996 multibpam sonar data, called SASS, was collected by the US Navy for the submarine program. Pieces of this data were released, and many ONR contractors came to the Navy to use this data for various purposes. In 1989 a stick-figure tectonic diagram of the Atlantic Ocean basin was published, and it showed that the fracture swarm megatrends meander, braid, merge, splay, start, and stop any place and are generally aligned with, or contain, the linear seamount chains. Geophysical data collected by satellite altimetry, Seasat and GEOSAT, were determined to be the equivalent of bathymetry as far as structural trends were concerned, and this opened up the southern ocean basins to be included in any working hypotheses. When compared to the available bathymetry, this seemingly jumbled tectonic structure was verified. The hot-spot tracks were shown to be trans-basinal, so that three complete sets of trends cross the basin. This is a physical impossibility within the constraints of the either the plate-tectonic or the Earth expansion hypotheses. However, placed in a surge tectonic framework, the reasons become immediately apparent. The fracture zones, one time eastward-flowing active surge channels that have emptied their loads to collapse and become large zones of mid-basin weakness. Reactivation causes the implantation of seamounts, the morphology of which are determined by the alignment of the pre-existing fractures. As the planet wobbles, younger surge channels flow, ever eastward, and cross the older, already bathymetrically imprinted surge channels. During the Cretaceous, the voluminous igneous outpouring created the large Pacific plateau and rises where several of these surge channel megatrends intersected orthogonally.

EARLY BATHYMETRY HISTORY

Matthew Fontaine Maury was the founding father of US Navy bathymetry. His idea was to collect all of the available ship's tracks and depths under one roof for use by all who went down to the sea in ships. From the 1850s this small beginning evolved into what would eventually become the US Naval Oceanographic Office (NAVOCEANO), and the data collected by that office would eventually help to shape ideas on what constraints were emplaced upon the formation of ocean floor features. This is an attempt to tie the two together by one of the people who was involved with the data collection, processing, and interpretation- me.

During the 1940s and 50s Harry H. Hess would visit NAVOCEANO (then called HYDRO for the Naval Hydrographic Office) during his yearly two-week Navy Reserve duty stints to work with the bathymetry data, which were stacking up in no particular order. He discovered the flat-topped seamounts in the Pacific basin during World War II, and he named them "guyots" after one of his professors at Princeton (Hess, 1946). Guyots would eventually be used to prove seafloor subsidence. Hess also suggested a way to organize the disarrayed data into Bottom Contour (BC) maps. The BCs became ten degrees in latitude at a four inches per degree of longitude scale in 1949. The purpose was to make files available to the scientific and maritime communities, an extension of the original founding premise of the Navy's bathymetry effort. Hess was a "founding father" of the plate-tectonic hypothesis. Using Arthur Holmes' (1931) ideas about seafloor spreading, he expanded upon the subject (Hess, 1962). This was presumably the result of his studies at NAVOCEANO, a fact which demonstrates the time lapse between the actual discovery of a scientific process and the acceptance of same. Seafloor subsidence and spreading became integral parts of the plate-tectonic hypothesis.

Many more academicians came to use the data, so Maury's original spirit in founding the library was still extant. As an example, Bruce C. Heezen of Lamont-Doherty Geological Observatory (LDGO) and Marie Tharp would bring grocery carts in to move the documents down the halls to be copied, probably working on an Office of Naval Research (ONR) contract (Dick Murchison, pers. comm. 1997). Heezen had formulated the idea of a globe-encircling midocean ridge system, basing his theory on CHALLENGER, METEOR, and VEMA data and unifying the theory at HYDRO. Even though Leopold Kober had postulated the ridge's existence in the 1920s, it is to Heezen's credit that he followed up and proved the theory (Heezen, 1960). The midocean ridge system became the spreading center for the plate-tectonic hypothesis.

As a historical adjunct to the contouring philosophy of that time, Allen Lowrie (pers. comm., 1995) of NAVOCEANO was working for Heezen at L-DGO from 1963-68. Lowrie says that Heezen used bits and pieces of bathymetry in the North, Atlantic that he had gotten from NAVOCEANO. Heezen felt that the fracture zones connected compression features across the ocean basin. He had "discovered" the Mid-Atlantic Ridge and knew about seafloor spreading. He felt that the Earth was not expanding, so that the extra seafloor being produced had to be taken up somewhere, in this case the Appalachian Mountains on the west and the Alps on the east (The idea of subduction zones had not been presented yet). Heezen aligned his fractures perpendicular to the azimuth of the Mid-Atlantic Ridge, and that concept introduced the straight-line fracture zones for the North Atlantic Heezen and Tharp maps that we still see there today on seafloor maps seen by most of the literate population. Seen as extensions of transform faults (Heezen and Tharp, 1968), the fracture zones were theorized to show the direction of seafloor spreading in the plate-tectonic hypothesis. For the North Atlantic, the fractures were drawn to verify the Bullard fit, whereby Massachusetts, USA was connected to Morocco on a WNW--ESE alignment, or spreading direction.

Before 1960 depths and ship's tracks were not analyzed. In fact, shoals and shallows were all that mattered because they were considered to be the hazards to navigation, the premise on which Mattew Fontaine Maury originally founded this office. Some of the maps looked like the modern data-dump computer-derived maps (Fred Sorensen, pers. comm., 1990). Events were soon to change. While the plate-tectonic revolution was coming to fruition, several events happened to change forever the face of the bathymetry and bottom contour maps. In the field of NAVOCEANO bathymetry, Joe Gilg and Fred Sorensen started more closely scrutinizing the data before contouring it into the maps. That idea was a revolution in itself because the old way of contouring was to put down lines and only pay attention to the shallows (Gilg, 1969; 1970). The Navy decided it could use unclassified regional planning sheets, so the civilian employees started contouring in earnest. These maps were called Naval Warfare Planning Chart Bases (NWPCB). At a scale of one inch per one degree of longitude on a Mercator projection, they served to organize the Navy's bathymetric data base. Remember, this was the time when the "all-embracing" hypothesis of plate-tectonics was being formulated.

To help in the submarine bathymetry effort, a new surveying department, called the Ocean Survey Program (OSP), was formed in 1963. It was the classified arm of the deep-ocean surveys, including bathymetry, gravity, and magnetics data collection. The Navy Navigation Satellite System was orbited to help navigation, LORAN-C nets were emplaced, an inertial navigation system (SINS) to help dampen the effects of gravity was added to the survey platforms. At first the ships used the 9° beam-width sonar to collect depth information for the submarine fleet to use for bathymetric navigation and depth calibration. Chuck Williams had developed a method for the submarines to get position fixes without coming to the surface by contour advancing. He also developed the early theories about surveying with bottom transponders. Transponders extended the range of our ability to survey sections of the deep-ocean that were not included in the LORAN nets. However, their range was limited to approximately ten miles.

OSP? What does this mean? It means seagoers who worked and played together. It meant giving a buddy a helping hand. It meant all pitching in for the common good, and it meant the best ocean floor data collection that ever has been. It means extremely accurate ocean floor maps used by the submarine fleet. It means Ocean Survey Program, one of the programs at NAVOCEANO. I worked in that program until it was disbanded in 1993, and this is the story of what should have been the effects of good deep-ocean bathymetry data on the tectonic thought processes throughout the latter half of the 20th century.

Using the "primitive" data collectors, OSP was at first tasked with finding the lost Air Force bomb off Palomares, Spain. Crewmember John Lenzer (dec) told the story: "We had been out for over five weeks, running out of everything. This outfit in Washington kept sending us coordinates to check on, but they all proved to be fruitless. Funny thing, a Spanish fisherman kept coming up to the DUTTON, trying to tell us something. Of course, nobody wanted to listen. Well, just about the time we had to go in, about 40 days into the cruise, somebody finally decided to listen to that fisherman. He told us that his fishing nets had kept getting hung up on something that had never been there. Sure enough, he had been catching that lost bomb." That is the extent of the technology at that time, in 1963.

DERIVATION OF THE PRIMARY PARADIGM

Earth scientists have now been married to the plate-tectonic hypothesis for about 35 years. This hypothesis has been proposed to be one of the five greatest scientific paradigms ever brought forward, being listed on an equal footing with the periodic tables in chemistry, the Big Bang theory in astronomy, evolution in biology, and Einstein's theory of relativity in physics (Wynn and Wiggins, 1997). The hypothesis purports to explain all of the geological phenomena surrounding us in our daily lives, such phenomena as earthquakes, volcanoes, continental drift, and the great extinctions caused by extraterrestrial collisions. This is all very exciting stuff.

In a brief synopsis of the historical events leading up to the formulation of that hypothesis, Alfred Wegener (1925) is given credit for deriving continental drift. Earth was predicted to be a series of plates separated by active seismic belts (Gutenberg and Richter, 1949). Large horizontal displacements on Earth's surface along great faults were noted (Hill and Dibblee, 1953). Deep earthquake zones around the Pacific were interpreted to be great thrust faults (Benioff, 1949; 1954). Large fracture zones were discovered in the North Pacific (Menard, 1955). Soon after this, North America was shown by magnetic pole displacement based on 180 million-year-old (Ma) rock samples (Runcorn, 1956) to have been displaced from Europe. The great rift system of the midocean ridges showed the dynamic state of the ocean floor (Heezen, 1960). Extensive magnetic patterns on the ocean floor which ended abruptly (Mason and Raff, 1961) verified fracture zones. Harry Hess theorized ocean floor spreading (1962). A paleomagnetic time scale using a mass spectrometer was developed (Cox, Doell, and Dalrymple, 1963). Earlier studies were used to solve Mason and Raffs magnetic anomalies (Vine and Matthews, 1963; Morley, 1986). Wilson (1965) showed that the magnetic anomalies were offset on formation along transform faults instead of after the magnetic signature had been imprinted. The transform faults proved to be the key, and the tectonic revolution was underway. At the 1966 Geological Society of America meeting in San Francisco, Lynn Sykes (1966) proved Wilson's hypothesis by studying earthquake motion, and Fred Vine (1966) tied it all together. This point is recognized as the start of the plate-tectonic revolution

Generally, all of the previous hypotheses and work are revealed in a fairly simple conveyor belt explanation, and this is the gist of the plate-tectonic hypothesis. Midocean ridges/spreading centers/divergent margins are zones of shallow seismicity where magma wells up to the surface from the asthenosphere and forms new oceanic crust. The crust moves and ages with distance away from the midocean ridge crest by "ridge push". The rate of movement varies but is measured in cm/yr. The new crust is subducted into the upper mantle in a region known variously as the subduction zone/Benioff zone/convergence zone or margin in about 180 Ma. The subduction zone is characterized by deep earthquakes. Continental and oceanic volcanic arcs form landward of the Benioff zones and are the foci of extremely virulent volcano and earthquake activity. Transform faults and fracture zones interconnect the midocean ridges and subduction zones. They are the foci of shallow earthquakes and are sometimes thought to be plate boundaries. Features not associated with those means of crustal production are generally attributed to hotspots, which are fixed diapirs centered in the mantle (Morgan, 1972). Through time, the ridges, transforms, and trenches may move about in no organized manner producing such phenomena as plate reorganizations, changes in plate movement direction, polar wandering, magnetic shifts, trench migration, and others.

"Plates" were discovered as an adjunct to the ocean floor hypothesis, and that is why it is called the plate-tectonic hypothesis. The plate boundaries are classified as divergent and convergent. The divergent boundaries are the midocean ridges. The convergent boundaries are subduction or collision zones where plate material is either consumed, accreted, or built upwardly. Newer fabric may be created there as the compressional forces buckle the meeting plates somewhat. Finally, the plates can slide past each other in a strike-slip action, leaving parallel ridge and trough structures. The plates join, or weld, at different times to other plate segments, which means that they react differently at different times. The rigid plate moves over Earth's spherical surface. As of this writing 12 larger plates are recognized: North American, South American, Pacific, Eurasian, African, Indian-Australian, Philippine, Antarctic, Caribbean, Scotia, Cocos, and Nazca. The microplates are the Mariana, Adriatic, Arabian, Juan de Fuca, Bismark, Solomons, Fiji, Magellan, Manihiki, Gorda, Easter, and several others. The number of plates continues to increase, the latest being the division of the Indian-Australian plate into two separate plates.

Hailed by the ocean floor community as the universal panacea, the plate-tectonic hypothesis was adopted *in toto* in 1966. The new hypothesis answered many questions about the origins and functions of the midocean ridges, continental rifts, fracture zones, volcano production and active arcs, deep sea trenches and the attendant Benioff zones, ophiolites, accreted melanges, etc. that had never had a satisfactory explanation.

The plate-tectonic hypothesis also had a shaky foundation; it was a sand castle. By 1966 not enough of the ocean floor had been sampled to derive any meaningful explanation about how the ocean floor formed, and that constituted about 70% of Earth's surface. The original hypothesis has not been updated since it was solidified in 1966, unlike other fields of science. Using anthropology as an example, when a new hominid skull is discovered, no matter where it is, all of the working paleo-anthropologists seem to take an active part in trying to find some way to create a niche for that fossil in relation to all of the other known fossils. If new hypotheses need to be formulated, which is usually the case it seems, a new one is formed. Generally there are at least two schools of thought. In the plate-tectonics field, when any updated geophysical data were introduced, an outward-seeming immediate gathering of the clan shut out any possible hypothesis-tweaking to accomodate the newer seafloor data.

Why? you may ask. So did I. Tectonics is the key to unlocking the structural geometry, and the regional geology is the key to unlocking the Earth's history. Lithosphere motions determine regional structure and the geo-morphology. A basic understanding of some tectonic theory is necessary to understand Earth geodynamics, and decent bathymetry of the ocean floor is a basic neccesity of that study. We look now at the history of the OSP bathymetry collection in an effort to unravel what went right, and what went wrong, with the formulation of the current tectonic working hypothesis.

ERA OF OSP BATHYMETRY

Two bathymetry outfits will be traced to show the converging path toward full bathymetry fruition. They are the Ocean Survey Program (OSP) and the World Bathymetry Group (WBG), both of NAVOCEANO. The WBG was formed and tasked with making unclassified charts for the surface fleet. The first worldwide bathymetry was done at a scale of 1"/degree of longitude. Gilg's idea was that more attention should be paid to the data and charts. He derived the idea of bathymetric evaluation where soundings were evaluated against the topography instead of the other way around (Gilg and McConnell, 1966). In retrospect, this proved to be one of the more monumental ideas concerning ocean floor mapping ever. Those maps were eventually used for the first gridded synthetic data base (SYNBAPS).

In OSP, the multibeam sonar collector, SASS, was put into use on three of the NAVOCEANO hulls, the USNS BOWDITCH, DUTTON, and MICHELSON, affectionately known as the "big grey pigs". The operational date was 12 July 1967. This was the first use of such a system in that, when employed with swath-mapping techniques, a total bottom contour image was possible based on 61--1°X1° beams. Guessing about actual events became passe. That fact alone established the SASS as the world's premier sonar collector, and NAVOCEANO was the only collection agency to use the SASS system. The data were collected in fathoms (fm) and nautical miles (nmi) because that was the standard unit of measurement for the submarine community. By the late 1960s the surveying philosophy evolved to favor regional surveys, whereby collecting classified bathymetric and geophysical data in various deep-ocean basins, progressing from north to south at a predetermined line spacing, became the mission. The charting unit was the Bathymetric Navigation Chart (BNC), compiled at a scale of 16"degree of longitude. One special project stands out.

In June 1968 the crew on the USNS BOWDITCH found the lost nuclear submarine, the USS SCORPION, using SASS and a magnetometer. Contrary to what is being presented in the popular press, the lost boat was not found by using the SOSUS data, it was not found in October 1968, and was certainly not found by Dr. John Craven, as is claimed (Sontag and Drew, 1998). We found it me using the 12-hour boat's positions, matching them to the available bathymetry of that time frame, and figuring a good route for the SCORPION to be taking at that time. The other surveyors were Herb Tappan and Rick Tyler, both now deceased. As it was, we hit the nail on the head and sailed right to it, finding the lost boat which had broken into four large pieces, the sail, the bow, the tail section, and the propeller and shaft. The position was 175 nmi from the position given by the SOSUS. You can put all of the other stories and speculations to rest. I was given credit for the find by the OSP office because I was the one who came up with the possible route. In fact, we had to go back down there after the July inport to calibrate the transponder net for the MIZAR, a research vessel that was dragging a picture-taking sled over the sub's remains. We compiled the net and programs for the MIZAR, drew the maps, and gave them to the MIZAR on-site through a high-line transfer with a destroyer that was on hand, presumably keeping an eye on the Russian trawler that was constantly in the area.

To show where this story will lead, I add this interesting sidelight. I had lunch with Norman Cherkis of the Navy Research Laboratory in Washington D.C. We were at an AGU meeting when, somehow, the conversation drifted to the SCORPION. Cherkis took full credit for finding the missing sub. I asked him if he was on the BOWDITCH or the MIZAR, just to set the hook. He said: "No, I found it without leaving my desk. I found it with the SOSUS". I have to wonder how many more finders that poor boat is going to have.

NAVOCEANO hierarchy decided to compile atlases of the northern ocean floor bathymetry. Coincidentally, a new twist entered the tectonic hypothesis at this time when Jason Morgan introduced the concept of hot spot tracks (Morgan, 1972). Using the Hawaiian chain, he expanded upon earlier ideas that the hot spot tracks on the ocean floor showed the direction of plate movement, in the case of the Pacific basin that would necessarily have been ESE--WNW. Considering that no reliable ocean floor maps had ever been compiled, this was a novel idea, and it will be discussed later. To rectify the fact that all of the world's bathymetry had yet to be compiled under one regime, Scripps Institution of Oceanography (SIO) was awarded a grant to compile the North Pacific atlas. NAVOCEANO sent people to help in that effort and published the results (Menard and Chase, 1971). The format was as 1"/degree bottom contour charts (BCs). The Mapmaker Seamounts were "discovered" during this compilation, and Joe Gilg stepped in to interfere before NAVOCEANO made the same mistakes. Contouring circles has led to many popular misconceptions about the seafloor. Gilg wrote: "...but when the Scripps maps came out, I thought mine were better. I believe I removed most of the significant position errors and got the forms and trends more accurate, at least to the extent the data were available. I also thought that my contour interpretations were better, because I was not afraid to guess that something was a continuous ridge, rather than a line of seamounts." (Joe Gilg, pers. comm., 1992). Later survey data and a change in philosophy in contouring broad areas with little data showed that some of these seamounts were merely the tops of the parallel ridges of the passing Mendocino and Surveyor Fracture Zones.

Meanwhile, the WBG was assigned the job of compiling the North Atlantic. Because the WBG was an unknown entity, an advisory group of experts from academia was appointed to oversee their endeavors. Heezen was on that panel as well as R.L. Fisher from SIO, B. Hersey from ONR, and E. Uchupi from Woods Hole Oceanographic Institute (WHOI). During this time the WBG and its advisors discovered that the contours did not agree with the pre-conceived notions espoused by the rest of the world's nautical cartographers: viz; N--S trends where E--W trends were theoretically supposed to be in the North Atlantic. The first trends were all N--S. After the discovery of fracture zones, the trends were all shown E--W. Fred Sorensen, while cross-training with OSP during the late 1960s, noticed that N--S-trending fabric existed between the E--W-trending fractures. He also noted bends in the fracture zones and the 30 nmi spacing of transverse faults through the midocean ridges in many areas, and the lack thereof in others. Sorensen took this information back to the WBG, and they updated their contouring accordingly (Fred Sorensen, pers. comm., 1988). The Atlantic atlas, published in 1973, was classified in part.

When enough of the NWPCB had been compiled, about 1972, the WBG assembled the information and invited the advisors, some of whom had been categorized as the "founding fathers", to see the progress being made. "You would have thought they were in a catfight. Everyone was trying to outdo or point the finger at everyone else. They could see that some of the tectonics theories were already wrong, and each was trying to defend his portion in the face of overwhelming data against all of them..." (Frank Marchant, pers. comm., 1994). It was at this point, 28 years ago, that an extreme course correction could have been applied to the current working hypothesis. It was not.

In 1974 the Navy had a change in surveying philosophy. A survey of the Tagus Plain off Portugal employed a three-mile line spacing with the SASS, wasted a month at $50,000.00 per day, and got about three contour lines per BNC. OSP sent me to the Global Ocean Floor Analysis and Research (GOFAR) Division to work with Peter Vogt, trying to establish some patterns from the 1974 SIO maps. Vogt trained me in the latest plate-tectonic ideas while we were doing this study. We matched our probable feature areas with those of the Gravity Division in OSP, and changed the way we conducted our surveys appreciably. One of those was not to waste time surveying abyssal plains any more.

The stage was set in 1974 for the full realization of the geography of the deep ocean floor, especially in the northern ocean basins. The world's bathymetry and science effort received a boost from an unexpected quarter. CDR John McDonnell started the release process for classified, SASS-surveyed, totally covered ocean floor features. Morris Glgnn and I were granted permission to publish data on select pieces of the ocean floor; he got the seamounts, and I got the guyots. The guidelines included not specifying that 1°X1° sonar data were used and not giving coordinates which located the geologic features to closer than a mile. We simply did not use the minutes and seconds. As for the unclassified bathymetry, Gilg took over the WBG and recruited R.N. Bergantino, who could show bathymetry by three dimensional or other means as another way for the users to visualize the bottom (Bergantino, 1971). "I tried to portray the third dimension uniformly, keeping the distortion of shapes to a minimum and keeping the location of objects or features as close as possible to true. The perspective part of the representation came from the methods of Raisz (1938), but I also used an idea by Robinson and Thrower (1957), thereby allowing a perspective map that was planimetrically correct". (Bob Bergantino, pers. comm., 1992) What this did was to supercede Heezen and Tharp's 1968 North Atlantic map by virtue of being based on the same data, better analyzed, with less vertical exaggeration. The perspectives were completed in 1974, and the originals were still in the bin when I retired.

In 1975 NAVOCEANO used the unclassified WBG bathymetry as an input into the acoustic model. To them fell the task of contouring all the rest of the world's ocean basins that had not been done to that point, and they compiled that onto an updated world map. Much of this information was proprietary, sketchy, erroneous; in short, it was ship-of-opportunity data. As an example, "...extrapolated morphology of midocean ridge-produced spreading fabric from the North Atlantic, a few lines of soundings, National Geophysical Data Center (NGDC) earthquake data were the guide for contouring the South Atlantic. This was definitely a dream sheet". (Lavern Snodgrass, pers. comm., 1995)

With the NWPCB on the shelf, Hersey wanted to produce a plastic relief model, and a digital data base would have to be completed to have values for that product. In 1977-78 only one of the "plastic pigs" had been produced, so the "pig" was dumped and the idea of the Digital Bathymetric Data Base (DBDB) was born. By now Hersey wanted to do a one-minute grid of the world maps, but he did not have the computer capacity or the data to support it. Tom Davis of NAVOCEANO introduced the idea of synthetic bathymetry. Davis was far ahead of his contemporaries in understanding the relationship of real data to gridded data and its presentation. Davis convinced him to make a five-minute grid instead (DBDB-5). The five-minute grid project was completed by the late 1970s, and digitizing started in 1980. ONR provided the equipment. It is now distributed by the National Geophysical Data Center (NGDC).

The "plastic pig" may not have worked, but some visionaries at NAVOCEANO have always been active in the latest presentation technology. In 1972-73 the SASS survey suite was used to survey Gilliss Seamount for Pat Taylor of NAVOCEANO, and he published a paper on it (Taylor *et al.,* 1975). This was the first SASS data ever published. In 1978 Gilliss Seamount came into focus again when Walter Jahn, a deep-ocean photographer for NAVOCEANO, took pictures using a remote sled of the flanks at discrete intervals over the entire range of Gilliss. He collaborated with Rob Nau, a surveyor and cartographer for OSP. "I built a 4'X4' table model of the seamount using pencil shavings, sand, and Eimers glue." (Robert C. Nau, pers. Comm., 1996). The vertically exaggerated model was finished in 1979, "when it went on the road. The model and photographs were displayed in the New Orleans Museum of Art for two months in 1980. From there the display went to the Natural History Museum in San Diego in 1980, the Science Museum of Minnesota in St. Paul, the National Space Technology Laboratories in Bay St. Louis, the Smithsonian Institution Museum of Natural History in Washington DC, the American Museum of Natural History and the Intrepid Sea-Air Space Museum in New York, and the Chicago Museum of Science and Industry, finishing it's tour in 1984." (Walter Jahn, pers. comm., 1996) This was the most publicized use of SASS information to date.

OSP was not necessarily involved with pure science, being instead more involved with data collection. Nevertheless, several of us over the years have tried to dabble in the arcane arts if for no other reason than it was difficult to do our job without a working knowledge of the geodynamics of Earth, especially since we saw so much of it. Because we were deep-ocean surveyors and cartographers, and because we had access to such high quality data, we had to research the literature to learn about the plate-tectonic revolution and to try to make the real bathymetry fit those constraints in our writing. Our real survey data disagreed with much of the hypothesized data, so the release process from NAVOCEANO was made all the more difficult because the ramifications of disagreeing with the then current hypotheses on ocean floor evolution were not realized at first. Dealing with outside reviewers who could never see the corroborating evidence compounded the problem. We started small, and Glenn finally got the first of the seamounts published in 1978 (Hollister *et al.,* 1978). Glenn did not publish any more ocean floor data to my knowledge, and I continued on a regular basis from 1980 (Smoot) until I retired in 1998.

OSP bathymetry was being introduced to many media. Many investigators outside the Navy community realized that all was not right with the published versions of many ocean floor maps. As an example, the General Bathymetric Chart of the Oceans (GEBCO), which is published under the auspices of the International Hydrographic Organization (IHO), has heeded the newer information on the real seafloor and has managed to show more or less the proper fracture spacing and trends since its 1984 (Searle *et al.)* North Atlantic chart. Marchant was on a GEBCO working group on digital bathymetry, so this may have been a factor. This influence has also been ignored in some instances. It seems that the wrong bathymetry has unfortunately been proliferated by the National Geographic Society (NGS) map series and others. The NGS map in 1975 (Grosvenor) showed straight, uniform fracture trends, which was reflective of the early Heezen and Tharp maps. The WBG had offered the five minute grid to NGS; who politely refused it (Frank Marchant, pers. comm., 1994). In 1990 (Garrett) the fractures were still straight on their representation, even though the spacing and pattern had been updated and appreciably changed.

On a positive note, the 1974 NGS globe provided immediate dividends for Earth scientists. It became possible to measure linear distances. Measurements of the linear distances of the "midocean" ridges, or spreading centers, and the convergent margins should have given a clue to the ocean floor scientists. The plate-tectonic explanation has ridge-push and slab pull as two of its possible driving forces. No spreading ridges exist on land; they are all in the ocean basins. New seafloor is created at the ridges. The amount that is produced must be taken up somewhere if the model is to have any validity. The hypothesis has neatly described subduction zones at sea and collision margins on land for those processes. But, let us look at the geometry. Everyone has access to a globe. Measurements with a compass yielded 74,000 km of midocean ridges. In theory, spreading is happening on both sides of the ridges, so new seafloor is produced along 148,000 km of the spreading centers. In theory, that much linear distance in convergent margins must exist to keep Earth from having a middle-age spread leading to another "big bang" situation. There is not; there are only 30,500 km of subduction zones and 9000 km of collision zones, only about one-fourth the amount of spreading ridges. This disparity in linear distance is probably an embellishment of the obvious. However, in an apparent community-wide failure to grasp the epitome of the situation, this fact has gone almost unnoticed by all but a few. Unless we believe in a rapidly expanding Earth, we must find some means other than the plate-tectonic hypothesis of explaining the geometry.

In 1981 the WBG was placed into OSP, and most of the Navy's deep-ocean bathymetry was finally all under the same regime. An Arctic group existed at the Navy Research Laboratory in Washington. For 15 years this was the state-of-the-art ocean floor-mapping consortium for the government. The DBDB-5 was finished in 1984 and sent to NGDC for distribution. The gridded bathymetry was not as good as the original data by the nature of grids in general. Only one data point per 25 nmi2 was used in the compilation, and a cubic spline and anti-aliasing device were applied to that. However, the DBDB-5 was, and still is, very good for regional studies.

In a continuation of developing new presentation ideas. W.E. Rankin of NAVOCEANO had developed a usable three-dimension program, and it was used to show several of the declassified SASS-based features. The old seamount models, such as the Gilliss Seamount, were retired from public service because of the computer. Pencil shavings and glue became a paper picture. One could do a primitive form of the flyaround on a feature. Because of the small amount of storage on the computers at that time, the grid spacing had to be necessarily large on the larger features. That led to a presentation that had the appearance of a fishnet (Smoot and Richardson, 1988), which is what they were called. Carrying a folder full of pictures was easier than a cumbersome model.

NAVOCEANO allowed many ONR contractors to use discrete segments of the bathymetry data during the 1980s. As such, much needed on-the-job-training took place to the mutual benefit of the Navy and academia. NAVOCEANO has helped with many scientific investigations by providing either regional bathymetry or specialized SASS surveys, which include the Cayman Trough for Troy Holcomb and the FAMOUS area of the Mid-Atlantic Ridge for J.D. Phillips and Hank Fleming (1978), all of the Navy. We also surveyed the newly formed Loihi Seamount for Alex Malahoff (1982), and the Galapagos triple junction (1979) and the initial site survey over the sunken TITANIC for Bob Ballard. Parts of the classified bathymetry data base on a "need to know" basis were released to the public. I was selected during this time frame as the point-of-contact for outside ONR inquiries in relation to the SASS bathymetry. During the brief period that the data base was open for inspection, many investigators passed through. Brian Tucholke studied the Kane Fracture Zone (Tucholke and Schouten, 1988). George Sharman used the data to establish trends in the NW Pacific basin. Don Hussong and Brian Taylor researched the Mariana region before cruises there. Dave Epp studied seamount morphology and distribution in the northern ocean basins, and we published those results (1989). We discovered that there were almost no on-ridge seamounts; plenty of knolls, but almost no seamounts. Will Sager came to study seamounts with me. We have already seen how Harry Hess and Bruce Heezen used the unclassified data. The list of those users is legion. The 1940s through the 1980s was truly a time of great interaction and mutual satisfaction between the Navy and academia.

The result of much of this bathymetry presentation and consequent discovery of new features led to the need for a means to identify at least the larger features. By 1985 many seafloor features had been accepted by the US Board on Geographic Names (USBGN, 1990), primarily named after NAVOCEANO ships and surveyors. One of the criteria for the USBGN naming procedures is in their section (2), paragraph (B): "Persons associated with the discovery and recognition of a feature..." From the WBG all of the compilers, after having discovered and contoured the Bathymetrists Seamounts off the coast of Africa, had discrete features within this cluster, named after them by Roger van Wykhouse and Reuben Bush: (Joe) Gilg Seamount, (Lavern) Snodgrass Seamount, (Dick) Murchison Seamount, Reedjones Seamount, (Fred) Sorensen Seamount, (Frank) Marchant Seamount, and others. I decided that the OSP surveyors were being left out after seeing so many features named after the "founding fathers" that I established guidelines for inhouse feature naming: the surveyor was to have taken at least 100 voyages of discovery, a lofty plateau in any seagoing circles. A partial list of the names accepted for use by the USBGN include: (Walter D.) Stout Seamount, Charlie Johnson Seamount, (John) Manken Guyot, (Tom) McCann Guyot, (John) Musgrove Seamount, (Alan) Jensen Seamount, (Dick) Vibelius Guyot, (Chuck) Jennings Guyot, (Jim) Maloney Guyot, (Commander Jesse) Sampson Guyot, (Captain John) McDonnell Seamount, (Charlie) Beatty Seamount, (USNS) Michelson Ridge, and (USNS) Dutton Ridge. All of these were associated with OSP. Stout, Manken, McCann, McDonnell, Jennings, and Vibelius are all dead now; so is the MICHELSON and DUTTON For help provided by outside researchers, features were named: (Allen) Lowrie Guyot, (Patty) Fryer Guyot, (Peter) Vogt Guyot, (Lou) Hemler Guyot, and (Rodey) Batiza Guyot.

As can be seen, my primary focus was on guyots and seamounts. We needed a complete understanding of seamount formation. The seamount evolutionary scheme is very important; it's relation to the fractures has been firmly established (Lowrie *et al.*, 1986). One stage of that evolution is the guyots, or one-time subaerial seamounts, of the western Pacific. Hess (1946) originally stated that the guyots were wave-planed subaerially. My initial studies were all related to guyots, and I redefined the parameters used to define those features after a statistical analysis proved that the definition needed updating (Smoot, 1983), and NAVOCEANO published those results (Smoot, 1991). Flank rift zones on most of the western Pacific guyots are aligned to the ENE.

Life was good. Things were working to everyone's mutual satisfaction. As is with everything else in the world that runs smoothly, something ugly usually rears it's head to try to destroy that very smoothness. In my case, it was several somebodies. I met Joshua Tracey of the USBGN at a JOIDES working Group meeting at SIO in 1985. He told me that he did not approve of the names I was submitting to the USBGN. I asked him why he had not rejected them if that was the way he had felt. I also questioned the reasoning behind having three features each named after Heezen and Menard. I asked him how many times we had to kowtow to the founding fathers. I had received some hate mail from such luminaries as Rudi Markl, who objected to my "hubris at naming seafloor features" (pers. comm, 1983), and from an Opinion in *Geology* (Fisher, 1987). I responded in writing (Smoot, 1988b) that I thought the rest of us who were actively involved in seafloor discoveries and mapping had paid enough homage to the ones who had gone before. The USBGN recognizes Heezen Fracture Zone, Heezen Gap, and Heezen Plateau. In fact, strange as it may seem, Fisher Seamount and Fisher Ridge lie off Costa Rica (Werner et al., 1999). I received "Comments" (Jackson and Fryer, 1991; Tucholke, 1990) on several articles (Smoot, 1988a; 1989b) and had to reply to them. In retrospect, it was at this point that the "Old Guard" started raising it's collective head against the newer interpretations allowed by the SASS data. For a more robust discussion of these events, see Smoot (1998b).

Investigators outside of OSP began to cast aspersions on the methods being used by the community as a whole to collect information (van Andel, 1981) and the means of its presentation (Feyerabend, 1984; Thompson, 1984; Costa and Sylvester, 1993), which included the then-current publish-or-perish philiosophy. Less-and-less people were reading more-and-more articles, so much so that the press was covered with essentially worthless information. The filter everyone applied meant to just stop reading other people's ideas, and this seems to be exactly what happened. If you did not think of an idea yourself, then make sure you downplayed whoever did. Closer to home, an article in Nature (Anderson, 1989) stated that the location of the seamounts in one of my articles (Epp and Smoot, 1989) was not presented with full accuracy. Not one feature I have ever published was off in the geographics by more than one-half a minute of the grid. That is less than one kilometer. We were releasing deep-ocean features that most people could never get the money together to go out an look at, much less do a detailed survey.

An example serves. I was a cruise with the Hawaii Institute of Geophysics (HIG). Hussong had blown-up a diagram of the Mariana Trough which was based on SASS data. We used that as a plotting base. The rest of the crew were amazed when bumps they were seeing on their sonar devices actually matched the published positions and bumps.

Undaunted, I still had a job to do. With the collection of SASS data came the need for employee training in the emerging science of seafloor geomorphology, a science that was so new that there was, and is, no commercially available textbook or laboratory manual on the subject. OSP had to publish one, and that was done in 1977 with updates in 1981, 1986, and 1993 (Smoot).

The beginning of the end was in 1985 when Vice Admiral John Poindexter of the National Security Council classified all multibeam data because the accuracy of even the commercially available SeaBeam was too fine (Staff, 1989). The National Oceanic and Atmospheric Administration (NOAA) had published a series of one-degree charts that had been totally surveyed with SeaBeam, and that effort greatly enhanced the community's ability to interpret seafloor events in Exclusive Economic Zone (EEZ). When the accuracy of even some of the most primitive harbor charts was demonstrated along with the amount of released SASS data, this really brought matters to a head. Oceanographer of the Navy Admiral J.R. Seesholtz did not want to give a free roadmap of our ballistic missile submarine egress routes to everybody, which brought NOAA's EEZ surveys to a halt (Staff, 1989). The world's free data base became progressively harder to access. By 1988 the availability of the original maps was severely curtailed to include Navy users only because the primary emphasis became the production of a half-minute grid (DBDB-0.5) classified data base. The basic premise of helping the scientific and maritime communities had been shelved, and I never helped another outside investigator who had come in through the front door. In April 1989 (Staff, 1989) the Oceanographer of the Navy Richard Pittenger lifted the ban on the release of the EEZ data except for the egress areas while keeping the prodigious OSP data base classified.

While the politicos tried to figure new and creative ways to stuff toothpaste back into the tube; that is, reclassify the already released bathymetry, the advancing technology for the contouring effort added yet another new tool to the bathymetrist's toolkit. In 1987 satellite altimetry (Seasat) data was added, although the satellite was prematurely turned off, euphemistically speaking of course. Even what little data it collected was light years ahead of what we had. Bill Haxby made a stellar map from the Seasat data that foretold what the GEOSAT would collect. His information was so good, that it was included as the Frontispiece in a Decade of North American Geology (D-NAG) volume (Haxby, 1987). Unfortunately, Haxby's map received no recognition. A SASS-based stick figure diagram of the North Atlantic fracture trends was published (Smoot, 1989b). This diagram was republished (Meyerhoff *et al.,* 1992) and then compared to the Seasat lineations (Smoot and Meyerhoff, 1995). The matchup was uncanny; it was almost exact. As an example, the Hayes/Oceanographer fracture swarm in the North ktlantic showed that the Bullard fit did not work; Massachusetts would have been attached to Portugal.

My primary scope of study changed to fracture zones about this time when the realization came that something else was amiss in the field, and definition, of plate tectonics. Later guyot studies (Smoot and King, 1993; Smoot, 1995a) added that the wave-planing occurred after mass wasting. The results of the mass wasting are the very chunks of rock lying about the flanks of the edifices. By finding the most summit plateau that appears smoothed; that is, above the summit plateau break depth, one can establish the height of the guyot. The height is the distance from the regional ocean floor to the summit plateau break depth. This idea was expanded by using the guyot heights to contour a paleo-fracture zone trend from the Hawaiian-Emperor "elbow" to the western Pacific trenches. Also, the placement and number of seamounts per unit area (Jordan *et al.,* 1983; Smith and Jordan, 1988) has nothing to do with plate thickness or proximity to a ridge as we can see by the very existence of these fractures and the absence of a continuous belt of high heat flow (Woodhouse and Dziewonski, 1984; Anderson, 1999). Leaky fractures are the progenitor of seamounts, and this is nowhere more evident than the linear seamount chains. Those chains are part of the megatrends.

The Mendocino Fracture Zone has been traced eastward from the western Pacific active arc to the Hawaiian/Emperor elbow both bathymetrically (Smoot and King, 1997) and magnetically (Nakanishi *et al.,* 1992) to a point at 161°E longitude. While this is the region of the Jurassic Magnetic Quiet Zone, the flank rift zones on the Marcus-Wake guyots have been used to show fracture trends on a N56°E azimuth between the Dutton Ridge at 149°15'E longitude, the Mariana Trench, and 161°E longitude (Smoot, 1989a). A variety of devices showed the trans-basinal passages of the Chinook Trough (Smoot, 1995b; 1998a) and the Clipperton megatrends (Joseph *et al.,* 1993), all on the predicted WSW--ENE trend of the Pacific fractures.

A plot of the Pacific basin from the DBDB-5 yielded not only WSW--ENE trans-basinal lineaments, but also NNW--SSE trans-basinal lineaments (Fig. 1). They had to cross in an orthogonally intersecting pattern, and they did. This concept was not good for the plate-tectonic hypothesis because the fractures supposedly showed the direction of spreading. The ocean floor could hardly be spreading in two directions at the same time. This idea was shelved because of the absolute heresy of such an idea. I proceeded with a

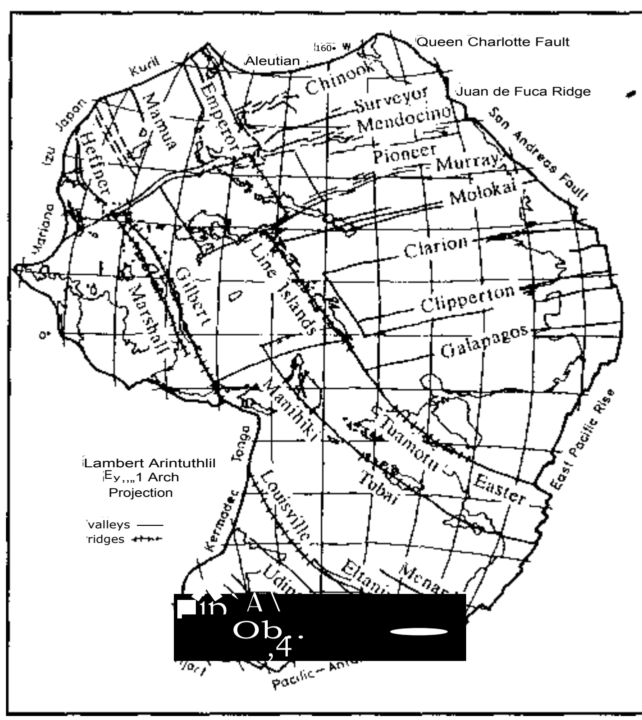

Fig.1. DBDB-5 base megatrends for the Pacfic "plate" region. The combination of ridges, seamount chains, and valleys has been available since 1974 and was drawn within the plae-tectonic constraints. To my knowledge, nobody has published it other than me. It clearly shows the orthogonal fracture zone intersections. Even the most myopic of students of the ocean floor could bave seen where the plateaus and rises lay (from Smoot, 1993; 1994).

note of caution as to actual ocean floor events, especially when enough SASS data had been collected to verify these findings. The orthogonal fracture zone intersections in the Pacific basin? They lay there on the shelf, fat, dumb, and happy in tectonic la-la land.

In 1988 another attempt was made to collect satellite altimetry data, called GEOSAT. The GEOSAT data were synthesized into a high-pass filtered data base (Meyerhoff *et al.,* 1996). The trends shown by this data set were proven to be the equivalent of the seafloor structural trends by comparing the satellite altimetry trends to the fracture zone trends (Smoot, 1989b) that had been established (Leybourne and Smoot, 1997). By extrapolation, the GEOSAT trends could be used to extend the long, linear seafloor trends in ocean basins where very little sonar coverage existed, such as in the southern oceans. Starting in 1989 we used these trends to help contour the long fracture zones we had data gaps in the bathymetry.

Another new tool came on line by 1989/1990 which was the equal of SASS, which had grown from a 61-beam suite to 121 beams. The full suite of Global Positioning System (GPS) navigation satellites became operational, and the Navy had access to the finest positioning for its bathymetry effort ever, the accuracy approaching centimeters.

Even the fishnet 3-Ds evolved. Under the auspices of inter-agency cooperation, NAVOCEANO got the Geographic Resource Analysis Support System (GRASS) package. GRASS is a raster-based Geographic Information System (GIS), developed by Baylor University, which can be used to process images and produce fine resolution graphic displays in three dimension. Computer memory is now virtually unlimited, what with two super computers on campus, so the 3-D is now only limited by the amount and resolution of data available. The end product sometimes has the appearance of a bottom photograph, except that it may cover thousands of square kilometers. Marine geomorphology came of age, or so I thought.

I tried many times to get the orthogonally intersecting fracture zones published, but this was an exercise in futility. Quixotic jousting with the plate-tectonic windmill became a course in establishing the fact that the pre-existing fractures; that is, the idea of where they lay, was actually trans-basinal. While this tactic of many "mini-papers" was counter to that advocated by others (e.g. Thompson, 1984; Costa and Sylvester, 1993) because of what was thought to be unneccesary clutter in the literature, the reviewers did not seem to be able to digest the entire concept of orthogonally intersecting fracture zones, removing the concept of hotspots, and ridding ourselves of the senseless micro-plates. The first step was tc name the fracture zones "megatrends" at the suggestion of George Sharman.

This is no mere piece of "scientific" fluff. Instead, it debunks the myth of the micro-plates in the introduction. On the GEOSAT geoid diagram (Smoot and Leybourne, 1997), many circular positive or negative gravity anomalies appear in the Pacific basin. The line of demarcation is essentially a "yin-yang" pattern for the Pacific plate, with the "zero" anomaly passing from the NW basin to the SE quadrant. The region to the west of this line of demarcation is the positive gravity geoid. The region to the east of the line is the nagative gravity geoid. Interestingly, the western anomalies all lie atop orthogonal megatrend intersections, which all coincide with the proposed micro-plates. They lie atop orthogonal megatrend intersections, which provide large zones of crustal weakness. During the great Cretaceous outpouring (Coffin and Eldholm, 1993) any number of Pacific seafloor features formed. Rather than being the generally accepted micro-plates and other ad hoc features, they are the modern plateaus and rises, such as the Manihiki Plateau lies on the intersection of the Galapagos Fracture Zone and the Mamua/Tubai megatrend at 11°S and 164°W, the Magellan Rise at 7°20'N and 177°W lies atop the intersection of the same Mamua/Tubai megatrend and the WSW-ENE trending Clarion Fracture Zone, the Mamua/Tubai megatrend passes through the Mid-Pacific Mountains, which are intersected by the Murray Fracture Zone at 20°N and 170°E to 170°W, and the intersection of the Mamua/Tuba megatrend with the Chinook Fracture Zone (Smoot, 1998) lies under the Shatskiy Rise at 35°N and 160°E.

Had the DBDB-5 been used with an open mind in the 1970s, the NNW--SSE megatrends would have been discussed. Additionally, a third set of trends are known (Smoot, 1998c). Ian McDougall (1971) saw them as being caused by counterflows in the asthenosphere. Jason Morgan (1972) called them hot spot tracks. Crossing the already existing fracture zones. which showed the direction of seafloor spreading, hot spot tracks were also theorized to show the direction of seafloor spreading. They were legion in the North Pacific (Fig. 1). The GEOSAT extended the coverage of all of the trends. These trends were noted by other authors, who felt they may be the result of extensional processes (Winterer and Sandwell, 1987; Cazanave, 1994). In the original diagrams of the ocean-wide trends based on the high-pass filtered GEOSAT data base (Meyerhoff *et al.*, 1996; Smoot and Leybourne, 1997; Leybourne and Smoot, 1997), many trends going across the Pacific basin on the same azimuth as the Hawaiian Ridge were delineated (Fig. 2). At the same time, maps using low-pass filters have also been released to the public (mostly published by David Sandwell and Walter Smith in various journals). Always,

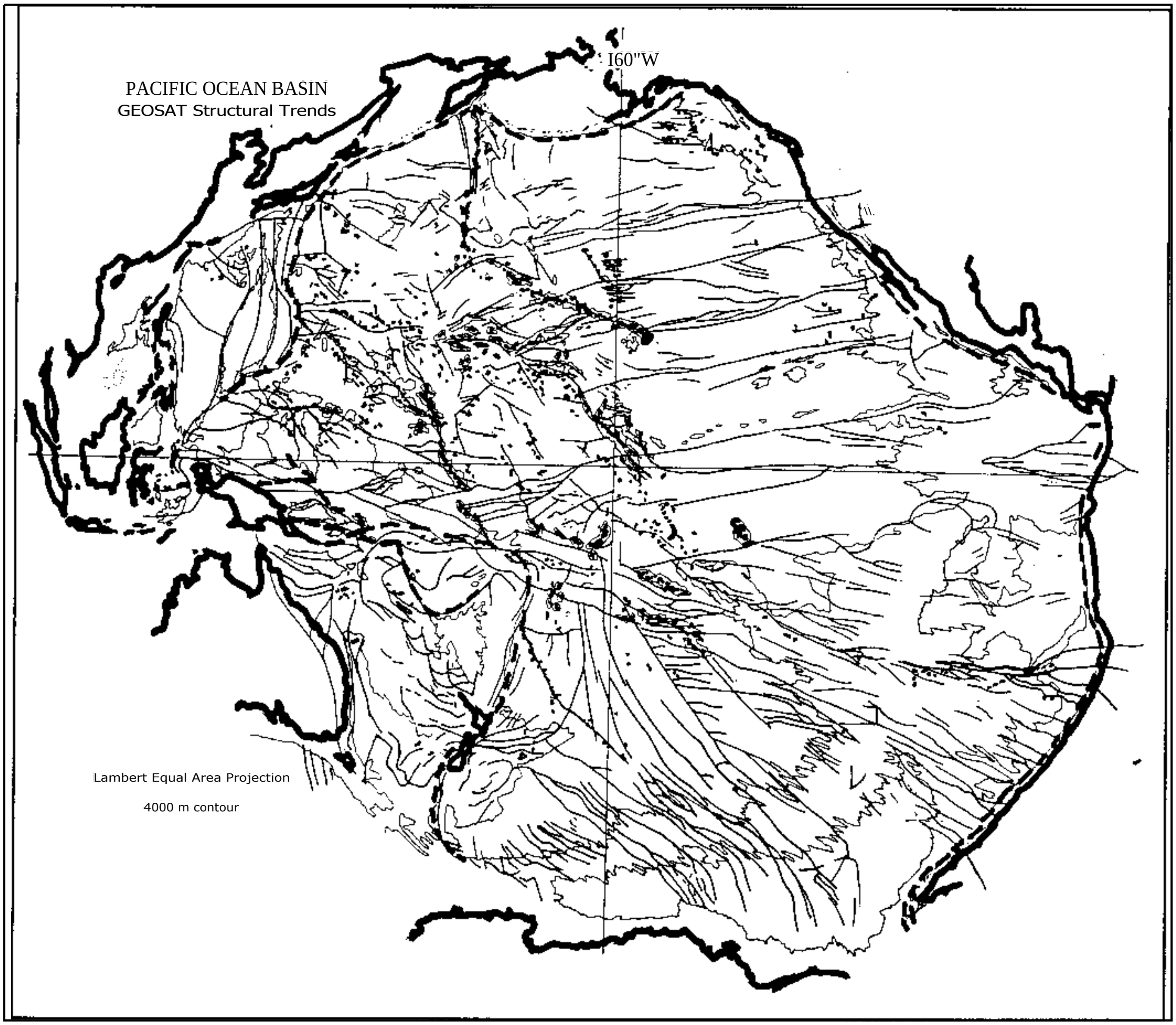

Fig.2. GEPSTAT based structural trends for the Pacific basin (Smoot, in press) By 1996 these had become megatrends and the concept of fracture swarms had been had been added. While the East Pacific Rise does not appear in the high-pass filtered data set, the other trends very readily appear. Not only are the NNW-SSE and WSW-ENE megatrends and intersections there but also the hotspot tracks have been shown to be hot lines instead which lie on a WNW-ESE trend. This gives cross-trends and helps explain such anomalous features as the Mid-Pacific Mountains and propagating rifts.

most of the WNW--ESE-trending lineaments are left out, with the possible exception of those agreeing with the plate-tectonic idea of hot-spot tracks.

With the full, robust survey suite now in place for deep-ocean surveying, OSP lasted only a few more years. In 1992 the dedicated, deep-ocean bathymetric surveys themselves were shelved until further notice by order of Secretary of the Navy Sean O'Keefe (Staff, 1992). The Magnetics and Gravity Divisions had been dismantled by 1993. OSP was no more. The newer emphasis was to switch from deep ocean, or blue water, to littoral zone, or brown water, surveying.

As to the collector platforms for OSP multibeam-surveying, the MICHELSON (1967-1975), BOWDITCH (1967-1986), and DUTTON (1967-1989) were replaced by USNS WYMAN (1979-1996), HESS (1978-1991), MAURY (1989-1994) and TANNER (1991-1993). The DUTTON collected the most survey miles, 2,471,758. The TANNER collected usable information for two years. As to the workhorse ships, by late 1996 the last SASS system was removed (WYMAN; Smoot and Murchison, 1998).

THE NEED FOR A TECTONIC PARADIGM SHIFT

We have been presented a skeletal history of the creation of the plate-tectonic hypothesis. We have been presented a more in-depth history of the bathymetry effort, probably because I lived and did, or was associated with those who did, that. We have also been presented where and by what means course corrections could have been applied to the working hypothesis. Throughout this paper I have focused on the fracture zone lineaments because they more fully cover the. topic of basin tectonics. They are basin-wide, ubiquitous, and certainly not esoteric by any stretch of the imagination. They have been known about since 1955 (Menard). I published the initial trans-Pacific Mendocino Fracture Zone (1989a) and the results of a "superchart" study as a stick-figure diagram of the fracture valleys in the North Atlantic (Smoot, 1989b). At that time the realization came that volcanoes were fracture controlled. Eventually they would all be acted on by someting that not only caused mass wasting, but was also a limiting factor in the volcano's eventual morphology. When so many of the flank rift zones of the Mid-Pacific Mountains and the Marcus-Wake guyots were aligned, there had to be some common cause.

Taking that part of the story a step further, in 1991 I started trying to get the orthogonal intersections published. I will not list the journals and societies, plus the one "friend" I lost due to the idea. I will merely say that one abstract (Smoot, 1994) was all that came out until *Geomorphology* decided to publish the results (Smoot, 1999). By then I had added the WNW--ESE-trending megatrends (Smoot, 1998c), but I decided to stay with what I had been able to get through the reviewers for a major publication, having spent eight years trying to get that idea across to the public. The concept of fracture zone/megatrend intersections is anathema to both the plate-tectonic and the Earth expansion hypotheses to warrant a complete overhaul of the basic premises of these hypotheses. However, we need not stop there after delving so far into the inner workings of such outdated ideas, ideas which have not evolved since their inception. That alone is a scientific disgrace. It is not the only one.

The problem of geometry has already been covered with the exception of the subduction process. It has been disproven by many authors (Smoot, 1997 for example), thereby removing yet another facet, slab pull, from the driving forces of plate-tectonics. The third problem is one of continental drift and paleobiogeography, meaning "where the critters lived a long time ago". Those of us who are familiar with the concept of continental drift (Wegener, 1925) are also familiar with the concept of a Gondwanaland, especially the role of the Indian subcontinent. At a symposium on New Concepts in Global Tectonics held in 1998 in Tsukuba, Japan, I had occasion to talk with a long-time researcher at the Wadia Institute of Himalayan Geology, Ismail Bhat. Bhat told me that the Institute had fully researched the proposed site of the Tethyan Sea, which would necessarily lie in the Himalayan Mountains between the Asian continent and India. Bhat (1998) stated that he knew that India had been stationary since the Late Archaean based on the existence of several kilometers thick of Precambrian and Palaeozoic sediments, that this fact had been suppressed, and that the fact had been known since the 1970s. The ancestral basin is dated at 2.51 Ga, and it began with a volcano-sedimentary sequence. Apparently continental drift is a non-event, and plate tectonics is starting to look much slimmed down from its original position as a heavyweight.

The fourth problem is one of geology and age. The Deep Sea Drilling Project (DSDP) set sail in 1968. The purpose of that project was to obtain basement material at predetermined sites. The idea was that a cored sequence could be used to solidify the magnetic anomalies and, as a result, the plate-tectonics hypothesis. Not one of the off-ridge cores on the supposedly 200 million year old crust ever reached basement; that is, none penetrated the overlying sediments to base rock. But, that is not all. Another inherent problem has also existed with the geology. The principal investigators have, by direction or otherwise, misrepresented the actual rock ages and types. In a summary article of the history of the DSDP/ODP in the Fall 1998 *Marine Technology Society Journal*, Thomas Davies states that "...indeed we have yet to find rocks older than 200 MY in the deep oceans. These observations lead to rapid acceptance of plate tectonics." Enough examples exist to show the extent of that coverup through dredge and drill data. Many continental rock types, trilobites, graptolites, and rocks in excess of one billion years old have been found all over the seafloor, yet they are not addressed by the very people who discovered them. I feel that the reason is because basin "opening" is featured so prominently in the Bullard fit, continental drift, and the plate-tectonic hypothesis in general. When Davies wrote the article listed above, the rock age information was available to him from such sources as the *Canadian Journal of Science, DSDP Volumes 37, 43, and 58, Tectonophysics, Earth and Planetary Science Letters, Science, GSA Memoir 132, and presumably, all of the USSR Academy of Science Transactions.*

Trans-oceanic megatrends, orthogonal megatrend intersections, no micro-plates, no continental drift, no seafloor spreading, no subduction, and ocean floor in excess of 1 Ga; what has plate tectonics come to?). During the last 15 years seismotomographic data have shown that mantle diapirs do not exist, there is no discernible pattern of upper and lower mantle convection, and the lithosphere above the asthenosphere, between 80 and 100 km, is permeated by a system of interconnected low-velocity channels. These data have taken away a driving forces of plate tectonics.

A unifying concept is needed that would allow such iconoclastic data, backed by the actual geophysical data, and that unifying concept is the surge-tectonic theory (Meyerhoff *et al.,* 1992; 1996). In the surge-tectonic theory the surge channels drive the tectonics and, consequently, the geomorphology. The active surge channel is always trying to flow eastward because of Earth rotation. Earth tilt and Chandler wobble explain the different megatrend alignments. They also show how continental drift is not needed to put warm-weather critters, such as crocodiles, in the present-day polar regions. The filling active trunk surge channel is the midocean ridge. The active feeder surge channel is the linear seamount chains. The empty, collapsing inactive surge channel is the fracture zone. Occasional dribbles of lava in an inactive channel will produce later seamounts. These appear in combination, such that seamount chains, fracture valleys, and fracture ridges are continuations of each other.

Where they intersect, these anomalies are called vortex structures. Positive vortex structures are regions of upwelling, and the features residing there are called rises and plateaus.

CONCLUSION

My participation in the tectonic "discussions" almost ceased in the late 1980s when I became tired of trying to publish in a hostile atmosphere, one that had been so receptive before the commercial availability of the multibeam sonar surveying technology. Additionally, the Navy was becoming more reclusive and proprietary with their data. More and more computer "specialists" who did not know anything about ocean floor processes were being placed in the positions of responsibility. They wanted a quick, computer-driven map. Having access to the world's largest and finest bathymetric data base for all those years, showing it to outside investigators, and then having all of the review process turn on me when I tried to publish the results left me rather jaded and with the proverbial bad taste in my mouth. Seeing the data first hand as I did on 67 cruises oceanwide was exciting, especially the shoal investigations and dropping XBTs down the craters to see if they were active. Almost running over a sub was included in the thrill. The 54-foot seas and 95-knot winds that hit us one January in the Gulf of Alaska added more thrill, especially when the deck forward of the superstructure took a twist and added 24 cracks in the deck plates. Somehow arguing in print about who-names-what paled in comparison.

But I was not alone. A 1988 conference at the International Geological Congress in Washington, D.C., and the accompanying 1992 Texas Tech book, was the first concerted real start. From that idea spread a cadre of world scientists who are working in the field and realize that their data do not fit within the constraints emplaced by the plate-tectonics hypothesis. Anyone doing field work would realize this fact. The working group expanded so that they met again at the IGC in Beijing in 1996. A forum for investigative data was begun under the auspices of the *New Concepts in Global Tectonics Newsletter,* a quarterly newsletter now on it's tenth volume since that conference. A 1998 symposium held at Tsukuba, Japan produced a volume of extended abstracts 360 pages long.

What this means is that the working field people now have a forum to try to unravel the geodynamic mysteries of the Earth. It seems as though the journal editors and reviewers and the keepers and dolers of the science grant monies have banded together to prevent any of the newer seafloor data which is contrary to the plate-tectonic hypothesis from seeing the light of day. Unfortunately, they are also not passing all of the facts on to the students. However, the real world awaits those students, and they we not prepared. Truly, the time for a paradigm shift in Earth geodynamics is now upon us, and it is incumbent upon us to rise and meet the challenge. Alternates are being taught at the university level in both Japan and China.

As to the technology, the Navy removed the last of the SASS systems in 1996, only to adopt the Simrad sonar system. I took my swan song cruise aboard the newer USNS SUMNER doing a 100% coverage survey of the South China Sea. In the deeper areas, the newer, "better" technology produced what I called railroad tracks going down the sonar trace at the edge of the middle 61 beams. This offset was not corrected, even though we kept reporting that fault for several years. I do not know as of this writing if that problem has ever been corrected.

It is with deep gratitude that I thank Arthur A. Meyerhoff, my friend and mentor for just a few short years before he died in 1994. He used the fracture zone lineations (Smoot, 1989b) in one of his papers (Agocs *et al.,* 1992). After some correspondence, I went up to Tulsa for a weekend visit with the guru. We talked mostly about the ocean floor, and he related this tale of surge tectonics to me. I started writing and going to conferences again in 1995, and have enjoyed it since. My late work has led me to this point. I took this opportunity to outline in rudimentary form

any contributions I may have made to whatever the final tectonic hypothesis will become. Is that surge? I have no idea, but it is a stepping stone in that it uses real data.

References

AGOCS, W.B., MEYERHOF", A.A. AND Kis, K., 1992. Reykjanes Ridge: quantitative determinations from magnetic anomalies, *In:* CHATTERJEE, S. AND HOTTON, N. III (eds), *New Concepts in Global Tectonics,* Texas Tech. University Press, Lubbock, 221-240.

ANDERSON, A., 1989. Release of seafloor maps. *Nature,* 338, 448.

ANDERSON, D., 1999. A theory of the Earth: Hutton and Humpty Dumpty, and Holmes. *In:* CRAIG, G.Y. AND HULL, J.H. (eds), *James Hutton-Present and Future, Geol. Soc. London Spec. Publ.,* 150, 13-35.

BALLARD, R.D., HOLCOMB, R.T. AND VAN ANDEL, T.H., 1979. The Galapagos rift at 86°W: sheet flows, collapsed pits, and lava lakes of the rift valley. *Jour. Geophys. Res.,* 84, 5407-5422.

BENIOFF, H., 1949. Seismic evidence for the fault origin of oceanic deeps. *GSA Bull.,* 60, 1837-1856.

BENIOFF, H., 1954. Orogenesis and deep crustal structure; additional evidence from seismicity. *GSA Bull.,* 65, 385-400.

BERGANTINO, R., 1971. Submarine regional geomorphology of the Gulf of Mexico. *GSA Bull.,* 82, 741-752.

BHAr, M.I., 1998. Untenability of the Neo-Tethys: Okeanos was not a polygamist, *Proceedings of International Symposium on New Concepts in Global Tectonics,* 12-18.

CAZANAVE, A., 1994. The geoid and oceanic lithosphere. *In:* VANICEK, P. AND CHRISTOU, N.T. (eds), *Geoid and its Geophysical Interpretations,* CRC Press, Ann Arbor, 255-283.

COFFIN, M.F. AND ELDHOLM, 0., 1993. Large igneous provinces. *Scientific American,* 269, 42-49.

COSTA, J.E. AND SYLVESTER, A.G., 1993. *The crisis in scientific publication.* GSA Today.

Cox, A., DOELL, R.R. AND DALRYMPLE, G.B., 1963. Geomagnetic polarity epochs and Pleistocene geochronology. *Nature,* 198, 1049-1051.

EPP, D. AND SMOOT, N.C., 1989. Distribution of seamounts in the North Atlantic. *Nature,* 337, 254-257.

FEYERABEND, P., 1984. The expert as con man, *Sci. Dig.,* 92(2), 83.

FISHER, R., 1987. A proposal for modesty. *Geology,* 15(6), 583.

GARRETT, W.E. (ed.), 1990. Atlantic Ocean Floor. *Nat. Geog.,* 177, 61 a.

GILG, J.G., 1969. *Sounding evaluation and the bathymetric feature chart: Naval Oceanographic Office Presentation to the XI Pan American Consultation on Cartography,* Washington, D.C., 10.

J.G., 1970, A bathymetric evaluation of doubtful hydrographic data: *Inter. Hydro. Rev.,* 47, 114-121.

GILL, J.G. AND MCCONNELL, J.J. Jr., 1966. Non-existent seamounts: a case study. *NAVOCEANO IM,* 66-28, 12.

GROSVENOR, G.M. (ed.), 1975. The Physical World. *Nat. Geog.,* 148, 584a.

GUTENBERG, B. AND RICHTER, C.F., 1949. *Seismicity of the Earth and Associated Phenomena,* Princeton University Press, 273.

HAXBY, W.F., 1986. Frontispiece 2. *In:* VOGT, P.R. AND TUCHOLKE, B.E. (eds), *The Geology of North America,* Volume M, The Western North Atlantic Region, GSA, Boulder.

HEEZEN, B.C., 1960. The rift in the ocean floor. *Scientific American,* 203, 98-110.

HEEZEN, B.C. AND THARP, M., 1968. Physical Diagram of the North Atlantic Ocean, The Floors of the Ocean. *GSA Spec. Pap.,* 65.

HESS, H.H., 1946. Drowned ancient islands of the Pacific basin. *American Jour. Sci.,* 244, 772-791.

HESS, H.H., 1962. History of ocean basins. *In: Petrologic Studies, A Volume to honour A.F. Buddington, GSA,* 599-620.

HILL, M.L. AND DIBBLEE, T.W. Jr., 1953. San Andreas, Garlock and Big Pine faults, California, a study of the character, history, and tectonic significance of their displacements. *GSA Bull.,* 64, 443-458.

HOLLISTER, C.D., GLENN, M.F. AND LONSDALE, P.F., 1978. Morphology of seamounts in the western Pacific and Philippine basin from multi-beam sonar data. *EPSL,* 41, 405-418.

HOLMES, A., 1931. Radioactivity and earth movements. *Trans. Geol. Soci., Glasgow,* 18, 559-606.

JACKSON, M.C. AND FRYER, P., 1991. Comments: The growth rate of submarine volcamoes on the South Honshu and East Mariana ridges. *Jour. Vol. Geotherm. Res.,* 45, 335-345.

JORDAN, T.H., MENARD, H.W. AND SMITH, D.K., 1983. Density and size distribution of seamounts in the eastern Pacific inferred from wide-beam echosounding data. *Jour. Geophys. Res.,* 88, 10508-10518.

JOSEPH, D., TAYLOR, B. AND SHOR, A.N., 1993. The Nova-Canton Trough and the Late Cretaceous evolution of the central Pacific. *The Mesozoic Pacific: Geology, Tectonics, and Volcanism, Geophysical Monograph* 77, AGU, Washington DC, 171-185.

LEYBOURNE, B.A. AND SMOOT, N.C., 1997. Ocean basin structural trends based on GEOSAT altimetry data. *In: Ocean Technology at Stennis Space Center: Proc. Gulf Coast Chap. MTS,* 135-140.

LOWRIE, A., SMOOT, N.C. AND BATIZA, R., 1986. Are fracture zones locked and strong or weak?: New evidence for volcanic activity and weakness. *Geology,* 14, 242-245.

MALAHOFF, A., MCMURTRY, G.M., WILTSHIRE, J.C. AND YEH, H.W., 1982. Geology and chemistry of hydrothermal deposits from active submarine volcano Loihi, Hawaii. *Nature,* 298, 234-239.

MASON, R.G. AND RAFF, A.D., 1961. A magnetic survey off the west coast of North America, 32 degrees North latitude. *GSA BULL.,* 72, 1259-1265.

McDouGALL, I., 1971. Volcanic island chains and sea floor spreading. *Nature,* **231,** 141-144.

MENARD, H.W., 1955. Deep-sea channels, topography and sedimentation. *AAPG Bull.,* **39,** 236-255.

MENARD, H.W. AND CHASE, T.E., 1971. *Bathymetric Atlas of the North Pacific Ocean: NAVOCEANO Pub. Num. 1301-2-3,* Bay St. Louis.

MEYERHOFF, A.A., TANER, I., MORRIS, A.E.L., MARTIN, B.D., AGOCS, W.B. AND MEYERHOFF, H.A., 1992. Surge tectonics: a new hypothesis of Earth dynamics. *In:* CHATTERJEE, S. AND HOTTON, N. III (eds), *New Concepts in Global Tectonics,* Texas Tech University, Lubbock. 309-409.

MEYERHOFF, A.A., TANER, I., MORRIS, A.E.L., AGOCS, W.B., KAMEN-KAYE, M., BHAT, M.I., SMOOT, N.C. AND CHOI, D.R., 1996. *In:* *HULL,* D.M. (ed.), *Surge Tectonics: A New Hypothesis of Global Geodynamics,* Kluwer Academic Publishers, Dordrecht, 323pp.

MORGAN, W.J., 1972. Plate motions and deep mantle convection. *GSA Mem.* **132,** 7-22.

MORLEY, L.W., 1986. Early work leading to the explanation of the banded geomagnetic imprinting of the ocean floor. *EOS, Trans., AGU,* 67(36), 665-666.

NAKANISHI, M., TAMAKI, K. AND KOBAYASHI, K., 1992. A new Mesozoic isochron chart of the northwestern Pacific Ocean: paleomagnetic and tectonic implications. *Geophys. Res. Lett.,* **19,** 693-696.

PHILLIPS, J.D. AND FLEMING, H.S., 1978. *Multibeam Sonar Study of the Mid-Atlantic Ridge Rift Valley,* 36°N-37°N. *GSA Map MC-19.*

RAISZ, E.J., 1938. *General Cartography,* New York, McGraw-Hill. 370pp.

ROBINSON, A.H. AND THROWER, N.J.W., 1957. A new method of terrain representation. *Geograph. Rev.,* **47,** 507-520.

RUNCORN, S.K., 1956. Paleomagnetic comparisions between Europe and North America. *Proc. Geol. Assoc. Canada,* **8,** 77-85.

SEARLE, R.C., MONAHAN, D. AND JOHNSON, G.L., 1984. *General Bathymetric Chart of the Oceans (GEBCO) 5-08,* 5th Edition, Ottawa, Canadian Hydrographic Service.

SMITH, D.K. AND JORDAN, T.H., 1988. The size distribution of Pacific seamounts. *Jour. Geophys. Res.,* **93,** 2899-2917.

SMOOT, N.C., 1980. Interpretation of deep sea sounding data. *Tech. Pap. ACSM, Fall Tech. Meet.,* MS-2-D-1-10.

SMOOT, N.C., 1983. Detailed bathymetry of guyot summits in the North Pacific by multi-beam sonar. *Surv. Mapp.,* **43,** 53-60.

Smoor, N.C., I988a. The growth rate of submarine volcanoes on the South Honshu and East Mariana ridges. *Jour. Volc.Geotherm. Res.,* **35,** 1-15.

SMOOT, N.C., 1988b. Letter to the Editor. *Geology,* **16(6),** 573.

SMOOT, N.C., 1989a. The Marcus-Wake seamounts and guyots as paleo-fracture indicators and their relation to the Dutton Ridge. *Mar. Geol.,* **88,** 117-131.

SMOOT, N.C., 19896. North Atlantic fracture valley distribution and patterns. *Geology,* 17, 1119-1122.

SMOOT, N.C., 1991. North Pacific Guyots: NAVOCEANO *Tech. Note TN 01-91, 101.*

SMOOT, N.C., 1993. *Bathymetry: Collection, Processing, and Interpretation: NAVOCEANO Train. Man. TM 01-93, 299.*

SMOOT, N.C., 1994. Plate-wide Pacific trends-orthogonal fracture intersections, *EOS, Trans., AGU,* 75(25), 69.

SMOOT, N.C., 1995a. Mass wasting and subaerial weathering in guyot formation: the Hawaiian and Canary Ridges as examples. *Geomorph.,* **14,** 29-41.

SMOOT, N.C., 1995b. The Chinook Trough: a trans-Pacific fracture zone. *In: Proc. Third Them. Conf. Rem. Sens. Mar. Coast. Env.,* **2,** 539-550.

SMOOT, N.C., 1997. Aligned a seismic buoyant highs, across-trench deformation, clustered volcanoes, and deep earthquakes are not aligned with the current plate-tectonic theory. *Geomorph.,* **18(3/4),** 199-222.

SMOOT, N.C., 1998a. The trans-Pacific Chinook Trough megatrend. *Geomorph.,* 24, 333-351.

SMOOT, N.C., 1998b. Multibeam bathymetry and the public. *NCGT Newsletter,* 8, 4-8.

SMOOT, N.C., 1998c. WNW-ESE trends in the Pacific Ocean basin. *NCGT Newsletter,* **9,** *7-11.*

SMOOT, N.C., 1999. Orthogonal intersections of megatrends in the Mesozoic Pacific Ocean basin: a case study of the Mid-Pacific Mountains, *Geomorph.* (in press).

SMOOT, N.C. AND RICHARDSON, D.B., 1988. Multi-beam based 3D geomorphology of the Ogasawara Plateau region. *Mar. Geol.,* **79,** 141-147.

SMOOT, N.C. AND KING, R.E., 1993. Three dimensional surface geomorphology of submarine landslides on NW Pacific plate guyots. *Geomorph.,* 6, **151-174.**

SMOOT, N.C. AND MEYERHOFF, A.A., 1995. Tectonic fabric of the Atlantic Ocean floor: speculation vs. reality. *Jour. Pet. Geol.,* **18,** 207-222.

Smoo r, N.C. AND KING, R.E., 1997. The Darwin Rise demise: the western Pacific guyot heights trace the trans-Pacific Mendocino Fracture Zone. *Geomorph.,* **18,** 223-235.

SMOOT, N.C. AND LEYBOURNE, B.A., 1997. Vortex structures and the world-encircling vortex street: Case study of the South Adriatic basin. *MTS Jour.,* **31(2),** 21-35.

SMOOT, N.C. AND MURCHISON, R.R., 1998. Deep-ocean technology, bathymetry, and tectonics. *Proc. Internat. Symp. NCGT,* 178-183.

SMOOT, N.C. AND LEYBOURNE, B.A., 1998. Remotely sensed data contribute to the paradigm shift of ocean basin tectonics: the Banda Sea vortex structure as an example. *Proc. Internat. Symp. NCGT,* 262-267.

SONTAG, S. AND DREW, C., 1998. *Blind Man's Bluff Public Affairs,* New York. 352pp.

STAFF, 1989. Navy lifts ban on bathymetry. *EOS, Trans., AGU,* **70,** 532.

STAFF, 1992. *From the Sea: Preparing for Naval Service for the 21st Century. Dept. Navy White Paper,* 8.

SYKES, L.R., 1966. Mechanism of earthquakes and nature of faulting on the mid-ocean ridges. *GSA Annual Meeting Program,* 216-217.

TAYLOR, P.T., STANLEY, D.J., SIMKIN, T. AND JAHN, W. , 1975. Gilliss Seamount: detailed bathymetry and modification by bottom currents. *Mar. Geol.,* **19,** 139-157.

THOMPSON, K.S., 1984. The literature of science, *Amer. Sci.,* **72,** 185-187.

TUCHOLKE, B.E., 1990. Comment: North Atlantic fracture-zone distribution and patterns shown by multibeam sonar. *Geology,* **18,** 911-912.

TUCHOLKE, B.E. AND SCHOUTEN, H., 1988. Kane Fracture Zone. *Mar. Geophys. Res.,* **10,** 1-39.

UNITED STATES BOARD ON GEOGRAPHIC NAMES, 1990. *Gazetteer of Undersea Features, DMA,* Washington, D.C.

VAN ANDEL, T.H., 1981. The ocean floor closely observed: will it subvert marine geology? *Nature,* **289,** 9-10.

VINE, F.J., 1966. Proof of ocean floor spreading. GSA Annual Meeting Program, 229-230.

VINE, F.J. AND MATTHEWS, **D.H.,** 1963. Magnetic anomalies over oceanic ridges, *Nature,* **199,** 947-949.

WEGENER, A., 1925. *The Origin of Continents and Oceans, Methven and Co. Ltd, London,* 212 pp. (translated by J.G.A. Skerl).

WERNER, R., HOERNLE, K., VAN DEN BOGAARD, **P.,** RANERO, C., VON HUENE, R. AND KORICH, **D.,** 1999. Drowned 14-m.y.-old Galapagos archipelago off the coast of Costa Rica: Implications for tectonic and evolutionary models. *Geology,* **27(6),** 499-502.

WILSON, J.T., 1965. A new class of faults and their bearing on continental drift. *Nature,* **207,** 343-347.

WINTERER, E.L. AND SANDWELL, D.T., 1989. Evidence from en-echelon cross-grain ridges for tensional cracks in the Pacific. *Nature,* **329,** 584.

WOODHOUSE, J.H. AND DZIEWONSKI, A.M., 1984. Mapping the upper mantle: Three-dimensional modeling of Earth structure by inversion of seismic waveforms. *Jour. Geophys. Res.,* **89(B'7),** 5953-5986.

WYNN, C.M. AND WIGGINS, A.W., 1997. *The five biggest ideas in Science.* John Wiley and Sons, Inc, New York, 200pp.