THE PALEO DUTTON PLATEAU: A GEOMORPHOLOGIC CONUNDRUM

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ABSTRACT

Guyots on the Dutton Ridge are used to explain the pre-existence of a plateau in the NW Pacific region. The idea was basically proposed in a 1983 paper but was not proven until the discovery of the basin-wide N-S fracture zone/mega-trends and the orthogonal intersections in the 1990s. The proposal is based on the multibeam sonar-based morphology itself and the intersections of both E-W Mendocino/Surveyor megatrends and N-S Udintsev/Kashima megatrends converging there.

Keywords: Multibeam Bathymetry, Fracture Zones, Megatrend Intersections, Guyots

1. INTRODUCTION

Fully accurate bathymetric data for eight guyots from the Dutton Ridge are based on U.S. Naval Oceanographic Office (NAVOCEANO) swath mapping by the SASS multi-beam sonar system in the 1970s [1]. The Dutton Ridge is a major east-west 275 nautical mile-long (510 km) trending feature that intersects the junction of the Bonin and Mariana Trenches at about 20^{o}N latitude [2, 3, 4]. Its trend parallels that of the Michelson Ridge, which lies further to the north at the intersection of the Izu and Bonin trenches at about 25^{o}N.

A general history of the guyots is that they were discovered when U.S. Navy Capt. Harry Hess studied sonar traces from the North Pacific Ocean floor while he tracked his ship's travels from landings in the Marianas, Philippines, and Iwo Jima in World War II. He named the flat-topped features after Arnold Guyot, appropriately "guyots" [5]. In the 1960s the Navy decided that it was time to construct maps of the world's ocean basins [1]. Joe Gilg and Fred Sorensen started looking more closely at the ship tracks to determine the validity of the information [6; Sorensen, pers. comm. during years I worked with him]. Gilg was in charge of this effort at the US Naval Oceanographic Office (NAVOCEANO), and the World Bathymetry Group compiled the first maps by 1971. The effort proved fruitful, so the basins were contracted to various institutes for the "official" interpretations, Scripps Institution of Oceanography being the contracted to do the Pacific [7]. NAVOCEANO oversaw that effort, and the results were published in a bathymetric atlas (7; Fig. 1). Germane to this discussion, the Dutton Ridge, while remaining unnamed, was shown for the first time in its rudimentary detail. Therefore, one could say that the feature was discovered some time before 1978 by some unidentified ship of-opportunity data collected by some ship(s) with a sonar collector. The compiler of that particular region could also be called the discoverer of the Dutton Ridge.

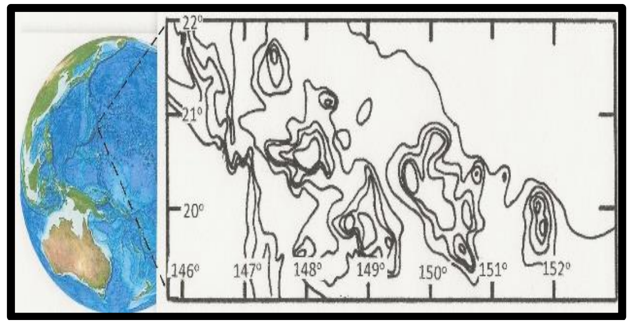

Figure 1. First full representation of the Dutton Ridge [7]. The feature was contoured at 200 fm using ship-of-opportunity single-beam data. Most of the features were recognizable in the proper locations. All in all, this was not a bad contouring job considering the quality and quantity of the information available at that time. This locator is contoured from that at 500 fm with the 3000 fm isobath on the upper right and at the trenches.

During the 1970s and 80s NAVOCEANO did a total-coverage, swath mapped SASS survey by the USNS DUTTON (T-AGS-22). In essence, NAVOCEANO could be credited with being the discoverer because of the reasonably accurate cartographic representations of the region. The maps had now become charts [8].

That brings me into the picture. I was tasked with compiling the chartlets on guyots with certain restrictions, getting the classified papers released through the proper chain of command, and finding an outlet for the publication of the guyots from NAVOCEANO's data base (Fig.2). This was rapidly growing by then with three ships of the line collecting data from the Atlantic and Pacific basins. To that end, I had published many articles [2; 8; 3; 4; 10] on the Dutton Ridge. The features had never been named, so I followed guidelines and named them after scientists who had helped with the project and sent the names to the US Board on Geographic Names (USBGN), with the terms: Dutton Ridge, Fryer Guyot, Vogt Guyot, Lowrie Guyot, and Hemler Guyot being accepted in 1983 [11]. I also named two of the guyots after long-time NAVOCEANO surveyors, John Manken and Tom McCann. These names have been used repeatedly in all of the above publications.

2. MATERIALS

Bathymetry for this project was collected with the 1^{o}-beam width Sonar Array Survey System (SASS). SASS was compensated for both pitch and roll while being updated with fresh sound velocity profiles at least four times a day [1; 10]. The swath mapping system used the 61 most vertical beams, and the sound velocities helped to predict the amount of outer-beam ray-bending. A roll-bias test was performed at the beginning of each cruise. The width of the swath was dependent upon the depth. The SASS has been replaced, and the newer systems are downgraded versions of that. The bathymetry collected using the SASS system was, and probably always will be, the best possible short of draining the ocean basins.

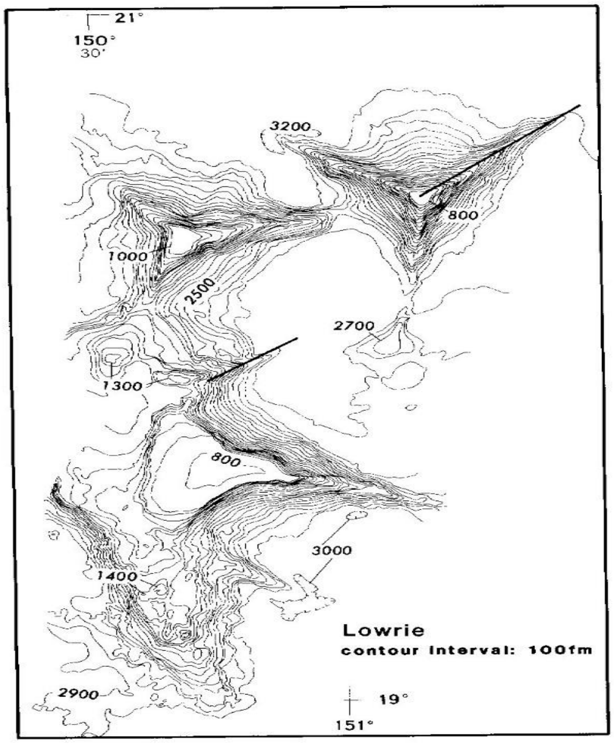

Figure 2. Lowrie Guyot and its attendant seamounts on the Dutton Ridge [2] at a 100-fm contour interval from the totally covered, swath mapped SASS data. I did, and do, not consider the attendants to be guyots although they reached the surface too. They do not have a broad enough flat top to qualify as having been eroded subaerially. For all three of the seamounts the flank rift zones are larger than what is considered normal, especially for such a small summit.

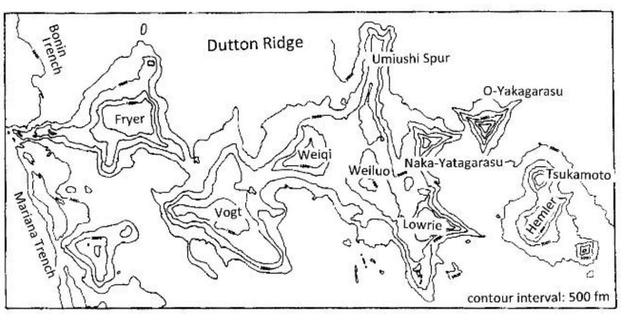

Figure 3. 500 Fm (914 m) Contour Interval diagram of the Dutton Ridge drawn from a SASS-based bathymetric chart. The three tectonic trends of about 305º lead one to consider fracture control, such as the formation of the seamounts in a pre-existing fracture swarm.

Geomorphic descriptions of the features used herein include (Fig. 3): Fryer Guyot (20º30"N, 148º00"E), Vogt Guyot (19º50"N, 149º00"E), Weiqi/McCann Guyot (20º10"N, 149º39"E), Weiluo/Manken Guyot (20º00"N, 150º10"E), Lowrie Guyot (19º40"N, 150º47"E), Hemler Guyot (19º40"N, 151º40"E).

Several other names have been applied to the smaller seamounts, and they are listed in the International Hydrographic Office's Data Centre for Digital Bathymetry (IHO DCDB) catalog which have been approved by the GEBCO Subcommittee on Undersea Feature Names (SCUFN): Umiushi Spur, Naka-Yatagarasu Guyot, O-Yatagarasu Guyot, Tsukamoto Guyot, and Aoki Seamount. All of these were claimed to have been discovered by the Japanese research vessels TAKUYO and CHIKYU in 2002, named in the IHO Gazetteer in 2018, even though they had already been discovered, and accurately surveyed, compiled, and published many years before. Also, because of their recent promotion to official names, Weiqi and Weiluo are used, which the Chinese claim was discovered by the DAYANG YIHAO in 2001. Interesting how history keeps being rewritten by whoever holds the purse strings. I had sailed with Manken as the senior scientist when I first went to work at NAVOCEANO. Practically spending his working life at sea, he was a legend as he surveyed all over the northern hemisphere.

Factors such as bathymetry, geology, geochronology, and geophysics all help in geomorphology. Basement samples of any of these features would help to establish tectonic events. Unfortunately, according to the report at the end of the Deep Sea Drilling Project (DSDP) Sites 1-625 as well as the Ocean Drilling Program (ODP) Sites 626-949 [1], no drill cores ever reached the true basement-NONE in all those years from 1968 to 2004 with all that money. In their own words: "Despite more than 30 years of ocean drilling, there are still relatively few drill holes in oceanic crust and a very poor sampling distribution in terms in terms of basement depth, crustal age, and spreading rate…" The Integrated Ocean Drilling Program (IOPD), which ran from 2004-2013, was never employed in the Dutton Ridge area, the nearest ones being across the trench on the forearc. While DSDP/ODP/IOPD were out collecting samples of detrital mud, the rest of the world was collecting samples from all over the ocean basins that were an order of magnitude older [12]. As of this writing no samples have yet been dredged from the Dutton guyots.

Several schools of thought can be considered from the geophysicists, one of which I am not. These schools include, geomagnetics, gravity, and earthquake seismology. From a geomagnetic standpoint, the NW Pacific basin has been labelled the Jurassic Magnetic Quiet Zone. Shipboard data has been synthesized such that this is possibly no longer the case [13; 14]. The Dutton Ridge lies within the purview of the Japanese Lineations Set, and it shows NW-SE trending FZs through the region. We know this to be a fact based on the bathymetric presence of the Kashima FZ/megatrend. Nevertheless, the discussion continues to this day as to the tectonics of that region and what can be used to determine that esoteric data set [15].

As late as 2014 Woods Hole was preparing a cruise through that region to try to solidify whatever data they could collect. Adjectives used to describe the magnetic anomalies do not inspire a great deal of confidence. According to one source [16], "The actual regenerative…are so low that the resolution is poor…The reexamination of the evidence for and against the reality of the pattern has produced intense controversy…We lack the key data to settle the argument." But the primary argument is: No spreading center exists for the northeastern Pacific basin, yet the depictions of the magnetic lineaments are there. From whence did they originate? One study showed [17] that the northward displacement of the region to the west of the San Andreas Fault has been found to be "entirely unnecessary," and that the tectonostratigraphic terranes can be just as easily explained by pluton tilt and sediment compaction. Therefore, the magnetic data also are of little use other than to show trends; they are not ground-truthed [18].

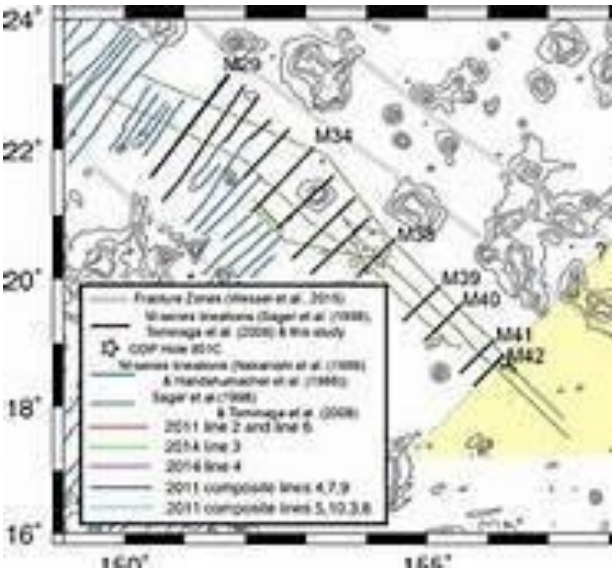

Figure 4. Interpretation of Seafloor Japanese Lineations Magnetics [15]. The southern portion of the Dutton Ridge is covered, but the trends are easily seen entering the sphere of influence. These are actually ground-truthed by the existing bathymetry (Fig.5)

A study of linear, hot spot formed seamount ages and the magnetic anomalies they lie on or near showed a different story when actual data were used [19]. Checking the seafloor spreading rate [20] for the Cobb hot spot trail shows a spreading rate of 7.9 n.m./1 Ma to Cobb Seamount, to Warwick Seamount 23.4 n.m./1 Ma, to Murray Seamount 39.5 n.m./1Ma, and Patton Seamount moved 1090 n.m. in 29.7 Ma (39 n.m./1 Ma). Similarly, the Bowie hot spot has produced seamounts younger in age the further away from the hot spot they formed. Trying to age anything on the ocean floor using magnetic lineation is an exercise in futility-it simply does not work. We will go with the orthogonally intersecting megatrends because we need to break up the original plateau.

3. DISCUSSION

Geomorphology of the features, all rising from a regional base depth of 5580 m [2, 3, 5]: Fryer Guyot rises up to two summit plateaus, one at 1320 m and a smaller one at 2560 m. The summit plateau break depth (SPBD) lies at 1650 m. Fryer forms an alignment with Vogt at 308º.Vogt Guyot rises to 1630m with a SPBD of 2000 m. Vogt has a major trend at 006º. Weiqi/McCann Guyot rises to 1425 m with an SPBD of 1650 m and trends 250º. It lies on a major 301º strike with Manken and Lowrie. Weiluo/Manken Guyot's summit is at 1740 m with an SPBD of 2210 m. Manken seems to be related to the Umiushi Spur, and they lie on a 000º strike. Similarly, Lowrie Guyot lies on a 000º strike with its northern neighbor, Naka-Yatagarasu Guyot. Lowrie rises to a 1450 m summit with an SPBD of 1650 m. Hemler Guyot lies off-ridge. At 1450 m height with an SPBD of 1465 m, it is commensurate to those features on-ridge. Hemler sits on a platform with Aoki Seamount and Tsukamoto Guyot, both minor edifices in the overall scheme of this paper. O-Yatagarasu Guyot lies on the E-W axis of the Dutton Ridge. Its summit is 1465 m. The overall morphology is accentuated by the three magnificent flank rift zones considering the size of the feature. The upper and lower flank slopes are such that any erosion appears only on the northern slopes, with that angle decreasing with depth.

Guyots are islands that have been subaerially eroded by wind and wave action, not to mention slumping [8]. Therefore, all of the Dutton Ridge lies in a clustered configuration similar to the Fiji and Azores Platforms. The summit plateau break depth (SPBD) on all of them should be the same. Fryer, McCann, and Lowrie are each at 1650 m. Vogt, Manken, and Naka-Yatagarasu are at 2000 m. The rest, Hemler, O-Yatagarasu, and Tsukamoto, have summit plateau break depths at about 1465 m. The southern flanks on Fryer and McCann are steeper. In fact, McCann, Manken and the Umiushi Spur all appear to have formed by later volcanism on a 2930 m tall platform which was already in place. The base depth within that confine is naturally 200-400 m shallower that the outside floor at 5580 m. While the outside regional base depth seems to be around 5580 m, that decreased toward the trenches to 5120 m, probably due to the outer trench swell (Figs. 2, 3).

The 305º alignments tell a different story. The westernmost group holds Fryer at 1650 m SPBD and Vogt at a 2000 m SPBD, a difference of 350 m. This is a sizeable difference. The next group to the east is the large platform holding Weiqi (1650 m), Weiluo (2000 m), and Lowrie (1650 m). The easternmost group contains O-Yatagarasu (1465 m) and Hemler (1465 m). All are guyots, all are lying in close proximity to the others. All were eroded at the sea surface at geologically speaking nearly the same time. Yet, they display different summit plateau break depths. Why would the northern tier be shallower than the southern?

The introduction of a presumably later-forming fracture from the ENE, the Mendocino megatrend [3], has raised havoc with features along its path, features such as Jaybee Guyot at the western end of the double trace of the Mendocino and Surveyor FZs (Fig. 5). The introduction of this megatrend into the pre-existing Dutton Plateau would be a great influence on the vertical tectonism of that feature.

The magnetic lineations map [15] provides geophysical evidence of this same scenario, giving the possibility of a NNE-WSW fracture swarm passing through the Dutton Ridge. It also lends verisimilitude to the Mendocino megatrend idea. However, caveat emptor- the ages assigned to these trends may be erroneous. As noted above, they are not ground-truthed.

Horizontal displacement occurred later when the NNW-SSE trending fractures appeared, features already in the bathymetry of the Udintsev and Kashima megatrends (Fig. 6). Later information, which was only introduced with the advent of the refined 3D presentation, shows a FZ coming through the Michelson Ridge to the north into Fryer Guyot. This is the presumed extension of Udintsev.

With the introduction of the intersecting Udintsev and Mendocino megatrends in the region of the paleo-Dutton plateau, one has merely to reconstruct the ridge backwards into the proposed plateau. The intersections could be seen as forming a checkerboard pattern at that point.

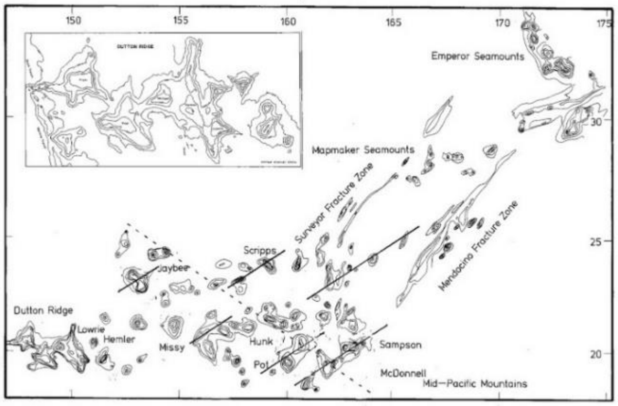

Figure 5. The Route of the Mendocino Megatrend from the Hawaiian Ridge to the western Pacific trenches [3]. The two FZs were greatly enhanced with the inclusion of the SASS survey data such that they turned more northerly and fit the overall scheme better. This goes through what has been called the Darwin Rise historically, but the regional base depth remains 5580 m throughout. No DR seems to have existed here [3, 21, 22]. The dashed line is the approximate location of the eastern fork of the Kashima FZ.

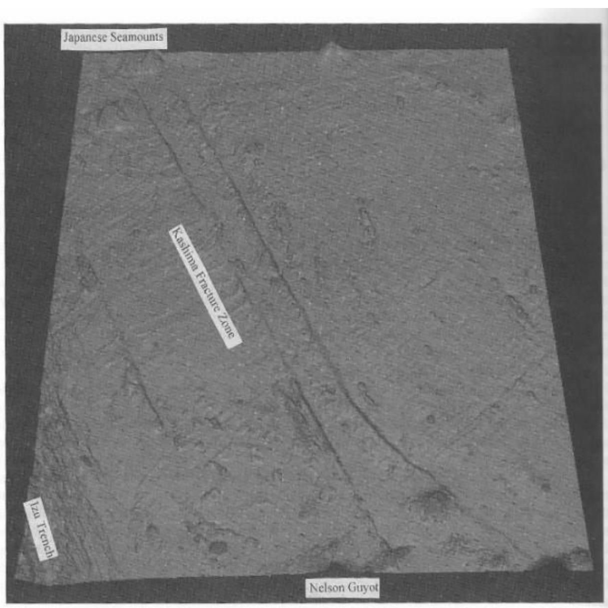

Figure 6. SASS-based 3D of the Kashima FZ from the Japanese Seamounts (Geisha Guyots) on the north to Nelson Guyot at the northern edge of the Michelson Ridge on the south [24]. Aside from the bifurcation which leads through the Marcus-Wake Seamounts, the western ridge is accompanied by at least one other near the trench. This is presumed to be the Udintsev FZ which will pass through the Michelson Ridge to enter the realm of the Dutton Ridge.

Fryer Guyot (Fig. 7) is entering the influence of the trench as its easternmost flank descends (more later). The western portion seems to have been truncated and shows severe flank slopes. Remove two FRZs between Fryer and Vogt Guyot and the two features fit like a "Bullard fit" with SW Fryer fitting the niche in NE Vogt. The two large FRZs would be aligned perfectly. Both features show reduced angle lower flank slopes carpeted by extreme outwash plains. Vogt shows the possibility of later summit activity by the two raised features.

The next platform to the west is separated down to the regional base depth. The 2930-m platform is home to three of the guyots: Weiqi, Weiluo, and Lowrie. The outwash plains are not as defined as those above, although the NW flank of Weiqi Guyot is commensurate. Most of the outwash rubble lies on the south, taking on the appearance of the Tuscaloosa Seamounts off Maui on the Hawaiian Ri dge. They could be the result of extreme mass wasting or of volcanic activity in a leaky FZ. The Umiushi Spur is an actual feature itself with the height being the same as the guyots and very little erosion present. The flanks are clean and have the same slope angles from top to bottom.

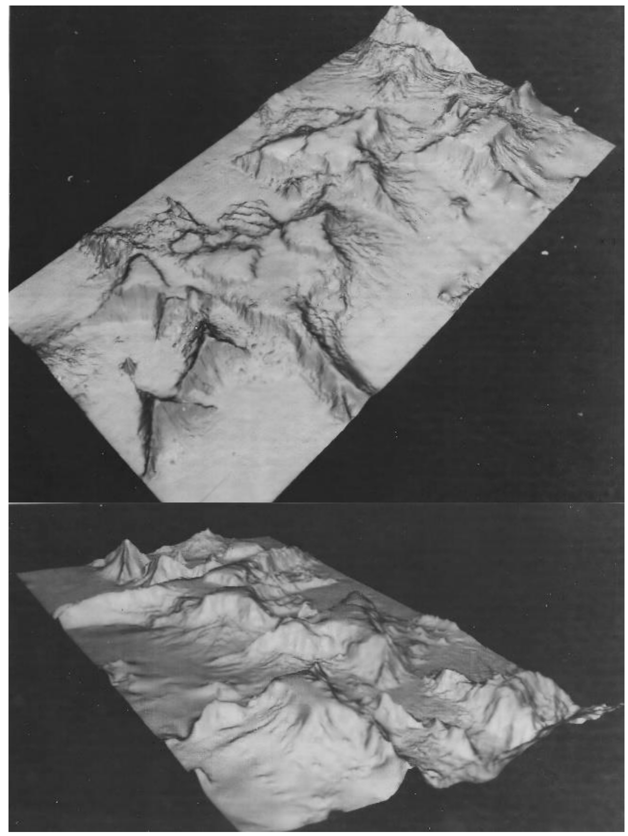

Figure 7. 3Ds of the Dutton Ridge based on a less-that-one-minute grid at a 5X vertical exaggeration. North is to the bottom-right in the diagram and north is to the bottom left in the bottom 3D. The advantage of using 3Ds is to better show geomorphic activity, especially when one is using a 200-fm contour interval.

Naka-Yatagarasu and O-Yakagatarasu may have formed at a later date as they do not show any signs of subaerial erosion or mass wasting of any kind. In fact, they look like Egyptian, or Mayan, pyramids with a few small flutes, or flank rift zones.

The unnamed seamount lying south of Fryer Guyot or, more specifically, the FRZ to the west, has not been discussed. What is left after the presumed subduction of the leading edge is in a direct line with Vogt, the platform guyots of Weiqi and Weiluo, and the outrider Naka-Yagatarasu and O-Yakagatarasu. This is the primary axis of the Mendocino megatrend.

Because of internal alignments and different summit plateau break depths in line on a secondary axis, the ridge was probably once more contiguous, in the form of a plateau. The direction of movement of the Pacific plate is currently thought to have been northwesterly for the past 43 Ma and almost due north from then into the Cretaceous. However, there is a fly in the ointment, several in fact. A southwesterly azimuth through the region from the Hawaiian Emperor elbow to the subduction zone where the Dutton Ridge presently resides has been proven to be the extension of the Mendocino megatrend. While this portion of the Pacific Ocean floor is overprinted by the Marcus-Wake Seamounts which presumably formed during the Cretaceous, evidence of the SW-striking features include multi-beam bathymetry coupled with flank rift zones and ocean floor tectonic fabric.

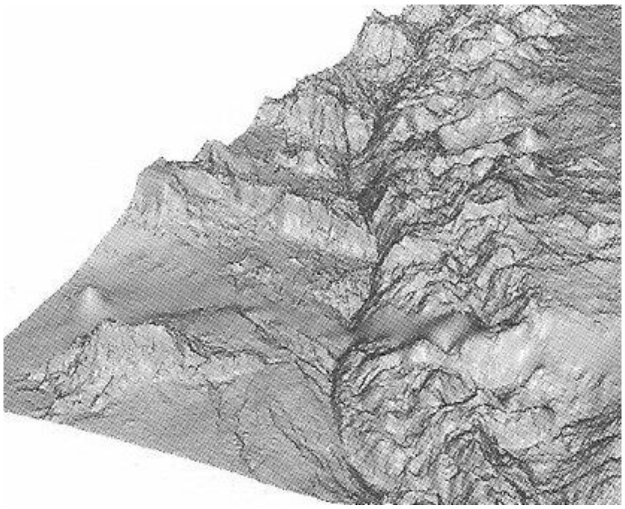

Figure 8. 3D of the Trench Region from the outer trench swell (left; [24]) through the trenches to the active arc on the right. The middle on the left is Fryer Guyot. Fracture traces approach Fryer from the north (bottom) as they pass into the unnamed seamount. These are presumably the northern extension of the Udintsev FZ from the South Pacific (Fig. 1). A seamount lies directly across the trench which could be a re-entrant or a volcano. The westernmost portion of the guyot is down-dropping into the trench.

Fryer Guyot is obstructing, and possibly obducting, the trench system (Fig. 8; [25, 10, 26]). A prime hint is the earthquake regime. The Bonin Trench on the north has a thalweg depth of 6450 m [27]. The Mariana Trench to the south of that has a thalweg depth of 6400 m, obviously discounting the Challenger Deep further to the south. They are on different azimuths, and their earthquake regimes are different [10]. In fact, very few events lie in and behind the trench system at this location. Rather than the deep events one would customarily expect according to the plate tectonic hypothesis, none exist here. A cluster of shallow-to-intermediate events exists at the southern extreme (between 18^{o} and 19^{o}), but no deep events occur along this trench system until 28^{o}-31^{o}N. I am not sure about the existence of two different trenches here. The difference in depths does not seem to qualify as a breakpoint.

4. CONCLUSIONS

I suggest that the Dutton Ridge formed as a volcanic plateau at an orthogonal megatrend intersection in the western Pacific basin. This once-continuous plateau was then fractured and faulted to produce the present group of guyots and ridges. Later volcanism may have altered its morphology. Subsequently, the ridge passively rode along on the Pacific Plate to its present location where it may be jamming the trench juncture, as indicated by a lack of seismic activity at that spot. In addition, bathymetric evidence indicates that the Dutton Ridge may have been partly obducted onto the arc-trench slope (Fig. 8).

No time frame is suggested because no good rock ages are available to make that determination. The final scientific crew on the ODP ship unequivocally made the statement that not one drill sample in the entire DSDP/ODP program had ever reached basement [16]. Additionally, the age of the magnetic lineations is unproven/unsubstantiated as recorded by many investigators. The breakup of the Dutton Plateau to form the Dutton Ridge is suggested to have been caused by fracturing.

So, until someone goes out there and picks up some actual rocks that fact will remain in Davy Jones locker well protected by an impenetrable layer of chert. Nobody knows what happened to the Dutton Plateau or why the cluster of guyots all have different heights and somewhat different summit plateau break depth. My guess is as good as anyone else’s.

ADDENDUM

These names were used repeatedly in 1983, 1986, 1989, 1991 and so on. They were originally surveyed by the USNS DUTTON (T-AGS-22) and the USNS MICHELSON (T-AGS-23). Claimed to have been discovered by the Japanese TAKUYO class and the CHIKYU (launched 2002) and the Chinese DAYANG YIHAO, they were not even on paper in the respective country’s eyes when the actual events took place up to 30 years before. Therefore, poor scholarship by the investigators/”discoverers” and people on the naming committee has led to the problem caused by overlooking the literature. From this list one can see that the IHO is rather fickle in who, or what, anyone else wants to name a feature. It is like picking up the scraps from the original presenter and rewriting the history of Pacific Ocean basin discovery.

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