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REPLY

Sediment and Geomorphic Criteria for Reconstructing Sea-Level Positions. Multiple Pliocene-Quaternary Marine Highstands on the Northeastern Gulf of Mexico Coastal Plain? Reply to a Discussion, *Journal of Coastal Research*, 14(2), 669–674 (1998).

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INTRODUCTION

This is a response to a rather perplexing Discussion (DONOGHUE *et al.*, 1998) to my criticism (OTVOS, 1995), regarding misapplied sediment and geomorphic information on northeastern and eastern Gulf coastal plain sectors. I have documented that numerous claims for marine littoral deposits, allegedly associated with high Pliocene-to-Late Holocene shorelines, have not been properly substantiated in the northeastern Gulf coastal plain.

In addition to a rather surprising number of misquotes and factual errors in the Discussion, its authors in the past failed to realistically assess sedimentary textures, structures, and various landforms as valid indicators of coastal lithosomes and ancient sea levels. Untested but firmly ingrained old misconceptions are being periodically perpetuated.

The Reply also takes the opportunity to point out a few problems with the treatment of beach ridge types and interpretations of their formation conditions. Serious limitations restrain the use of granulometric parameters and sediment structures as a tool for distinguishing between wave- and wind-constructed intertidal and supratidal deposits.

BEACH RIDGE CATEGORIES

In order to support the idea of higher-than-present Late Holocene sea levels, the individual authors of the Discussion, equated strandplain ridge crest elevations with sea-level positions (DONOGHUE *et al.*, 1998). Allowances for minor eolian/dune "decoration" on the beach ridges crests have been made only occasionally and without explanation. There are serious questions about automatically relating ridge crest elevations to given past sea-levels. The review of the available sedimentological and morphological criteria is therefore warranted to distinguish between different beach ridge types; "wave-built" and "wind-built" ridge categories. A more detailed treatment of genetic and nomenclature issues is being planned (OTVOS, in prep.).

(1) Intertidal Beach Ridges

These relict, "planar" beach ridges are rhythmically developed, prograded wave-built features that represent the foreshore and the high-tidal berm lithosome (OTVOS, in prep.). Exclusively sandy "berm" beach ridges commonly have low slope angles (4-to-7 degrees). Landward-directed overwash and subsequent wind erosion automatically limit vertical sand accretion above high tide level. Steeper ridges, composed of coarse shell and especially heavy gravel and cobble clasts ("storm ridges"), on the other hand, may remain stable and often rise several meters above MSL.

Intertidal ridges on the predominantly shell-free, medium-sandy, lower-microtidal northern Gulf of Mexico mainland and island shores on the northeastern Gulf generally attain only 40 to 50 cm above low-tide level. Unless interlayered with stabilizing sandy pebble layers and/or coarse shell beds, the subdued sandy berm ridges are ephemeral landforms. Eolian and overwashed sands fill the inter-ridge swales and bury the wave-built structures. In combination with spring tides, record low atmospheric pressures, and large constructive waves, induced by distant storms may raise tides 1-to-3 m above mean sea level even on microtidal shores. High-tidal swash zone sedimentation on preexisting beach ridges, including foredunes, may result in vertical aggradation, including the "plastering" of shelly sands with driftwood debris on beach ridge surfaces (*e.g.*, MASON *et al.*, 1997, Figure 7).

(2) Eolian Beach Ridges

Nearly all Holocene strandplain ridges on the Gulf coastal surfaces may be represented by prograded relict foredune

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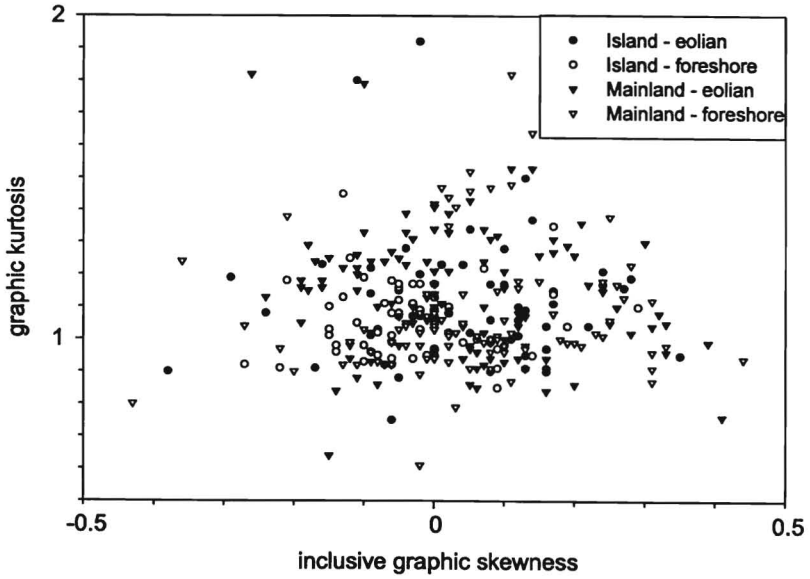

Figure 1. Skewness vs. kurtosis plots, based on samples from mainland and island foreshore and foredune/eolian backshore environments on Mississippi and Alabama beaches. Notice complete overlap between eolian and foreshore sand sample plots.

ridges. These often are not considered "real" beach ridges in the literature (OTVOS, in prep.). Steep and crisply defined, these elongated mounds overlie intertidal lithosomes. Their base, at the interface with the underlying intertidal-to-high tidal berm interval represents the elevation of the contemporary sea-level. Unfortunately, terrestrial snails that would be diagnostic indicators of eolian facies, have been very rarely reported from relict foredunes.

With the exception of a few sand-deficient but shell-rich Gulf beaches (south Louisiana and Florida Gulf coast sectors), foreshore zones generally provide adequate sand supply for eolian sand accumulation. Small foredune ridges frequently form even on sand-starved Louisiana shores. Overwhelmingly sandy, steep-sloped strandplain ridges on the Gulf mainland and island shores are to be regarded relict foredunes. Unlike the flat, wave-built sand "berm ridges", foredune ridges rise to 1-to-6 m elevation above present sea level (OTVOS, 1995, Figure 7; OTVOS, in prep.). Eolian strandplain ridge crest elevations (*e.g.*, St. Vincent Island strandplain ridges in NW Florida), for this reason can not be regarded as sea-level indicators.

Granulometric Parameters—A Tool for Distinguishing Between Foreshore and Foredune Deposits?

In contrasting intertidal beach sands with dune deposits, numerous authors (*e.g.*, MASON and FOLK, 1958; FRIEDMAN, 1961; VISHER, 1969) have demonstrated the more positively skewed nature of eolian deposits, with a dominant saltation, a minor truncated traction, and a small suspension grain population. Tanner (*e.g.*, in: BALSILLIE, 1995, p. 128–129) claimed complete separation between beach and eolian fields. Considerable transport distances from foreshore or fluvial floodplain sand sources may indeed enhance granulometric differences in eolian deposits, causing a marked increase in the "fine tail" sector.

At odds with his own conclusions, STAPOR (1975, p. 123) disclosed comparable results; near zero (Gaussian) skewness and uni-modality, but no firm distinction between "marine" and coastal dune origins of analyzed sands. According to him, the discussed east Florida Panhandle beach ridges "*probably*" formed by marine action. Convincing diagnostic data were not presented to support this contention. In terms of the presented statistical parameters nearly all the cited "swash-constructed" beach ridges differed from coastal dunes and from the present-day beach environments.

The close proximity of foredunes and eolian sheets to their foreshore source, as well as wave/swash-backwash, and wind-induced two-way mixing between the two depositional facies work against any significant changes in the "fine tail" sector. Skewness vs. kurtosis plots from ca. 350 eolian and intertidal sand samples resulted in total overlap (Figure 1). Samples included southeast Dauphin Island, AL, precipitation dunes that have migrated 250 m inland from their foreshore source and smaller intervening dunes. In contrast, MASON and FOLK (1958) and others indicated only minor overlap between beach and dune plots.

Statistical parameters thus provided no valid diagnostic tool for distinguishing between swash zone and wind-transported sands on the microtidal northeastern Gulf coast. No granulometric contrasts would therefore be expected to mark the horizontal interface between the wave-built base and the eolian ridge superstructure. This surface would identify the associated sea-level position.

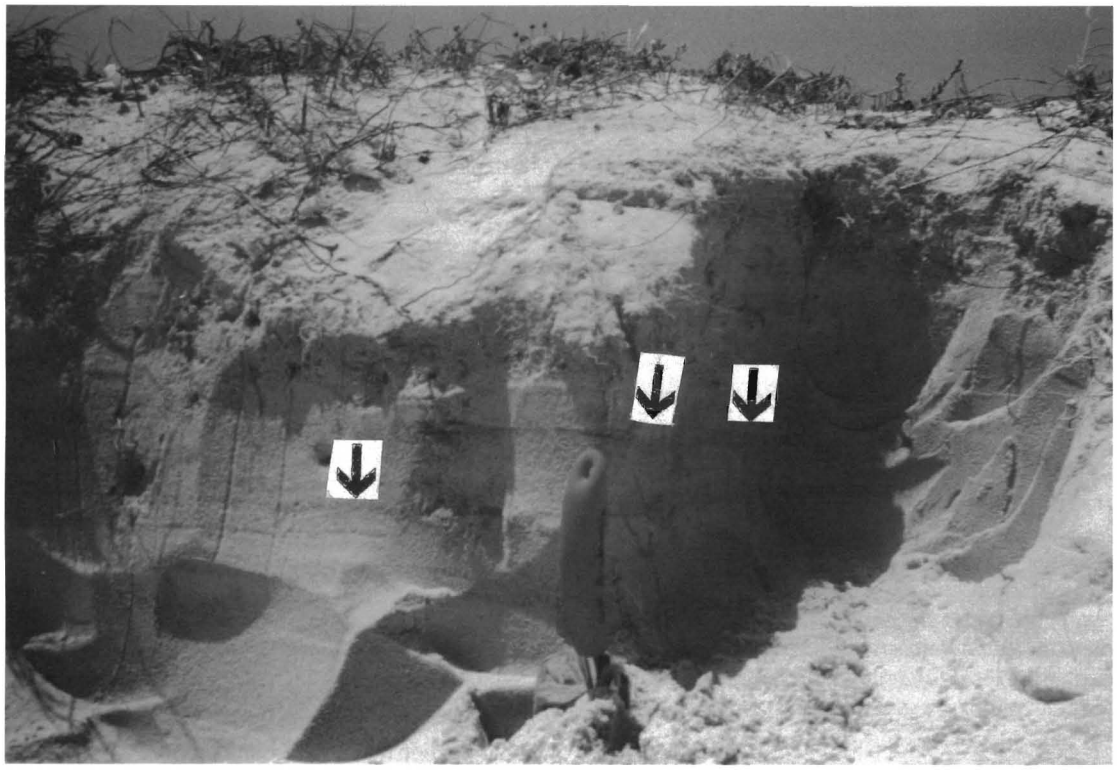

Figure 2. Horizontal, parallel, heavy mineral-outlined lamination (arrows) in eolian terrace sands. Dauphin Island, Alabama, Fishing Pier outcrop. Cuts are shore-parallel and shore-normal (compare with Otvos, 1995, Figure 6).

Sediment Structures—Discriminants Between Foreshore and Foredune Depositional Facies?

It would be an oversimplification to designate low-angle, parallel and cross-stratified, seaward-dipping layering as an exclusively *foreshore lamination* and steep cross-stratified beds as diagnostic only of *eolian* sand sheets and foredunes.

When accreted on flat backshore surfaces, *foredunes and eolian (dune) terraces* display parallel, subhorizontal lamination that mimics intertidal swash zone layering (RUZ and ALLARD, 1995; MASON *et al.,* 1997). Dark heavy mineral laminae in eolian terrace bluffs east of Dauphin Island's Fishing Pier, displayed near-horizontal, parallel layering both in shore-normal and shore-parallel cuts (OTVOS, 1995, Figure 6 and present Figure 2).

STAPOR (1975, 1991) had claimed the intertidal origins of Apalachicola Coast and western peninsular Florida strandplains and their lack of substantial eolian components. In the absence of adequate beach sand sources, minor eolian sand accumulations still takes place even in dominantly shelly beach ridges. Intensive man-created disturbance of the land surface may have destroyed eolian components in several shell-rich Florida strandplains.

Seaward dipping, low-angle parallel- and slightly cross-stratified shelly sands with closely *interlayered sandy shell layers that include large shell fragments of intertidal origin* (*e.g.,* STAPOR *et al.,* 1991, Figure 5) are common on sand-deficient Louisiana and western peninsular Florida shores. In addition to growing by vertical aggradation, as in Alaska (MASON *et al.,* 1997) and SW Louisiana (OTVOS, 1995), sandy shell beds, mixed with driftwood, may be also "plastered" onto and incorporated in foredunes during unusually high tides (MASON *et al.,* 1997). They do indicate intertidal (swash zone) deposition and/or overwash processes. In the absence of strong Gulf-wide evidence, their higher elevations alone are insufficient to support a Holocene highstand theory.

STAPOR (1975) and DONOGHUE *et al.* (1998) believed that gently seaward inclined planar sand laminae are diagnostic of intertidal deposition in Florida. Cross-stratified planar bed sets in Apalachicola coast exposures dipped at 10 to 28 degree angles and extended laterally for a distance of several meters. These were interpreted as indicators of a higher-than-present intertidal range, during Late Holocene eustatic highstand stages. The tidal range and wave conditions, associated with the 1.5–2.0 m high, wave-built, flat beach ridges in western Alaska (MASON *et al.,* 1997) in several aspects resemble those that accompanied beach ridge development on the faraway western Florida coasts.

Steeply inclined (10–30 deg.) cross-strata, capped by near-horizontal waning-storm layers, represent the intertidal core-lithosomes of the 4-m high Cape Espenberg dune beach ridges (MASON *et al.,* 1997, Figure 8). Eolian beds, composed of steeply-inclined to near-horizontal strata were draped over berm ridge "cores". This succession resembles the extensive "Locality Beach Ridge" exposures in the Late Holocene St.

Joseph barrier spit in NW Florida (STAPOR,1975, Figure 2, Photos 1 A–D). A steeply bedded intertidal berm core interval in the "Locality" bluff, approximately at present high tide level thus appears to be overlain not by intertidal but eolian layers of variable dip angles.

HOLOCENE HIGH SEA LEVEL MARKERS?

Higher-than-present Mid- and Late Holocene relative regional sea-level positions *have been* reliably demonstrated in several regions, including Australia, Pacific islands, and Singapore, to name but a few. Even if such highstands were brief, the associated lithosomes should be readily recognizable at numerous northern Gulf and Atlantic locations.

MORTON *et al.* (1997) have recently reinterpreted a number of inshore and littoral landforms, including "raised marshes", as reflecting slightly higher raised eustatic sea levels between 5-to-2.5 ka B.P.on the Texas coast. Some of these features used to be attributed to storm-raised, record high, tidal episodes, based at the present mean sea-level stand. Documentation of widespread *elevated brackish* marsh deposits along the Gulf mainland and estuarine shores would indeed be the cinching evidence for the suggested record highstands. Claims for elevated Late Holocene sea levels, based on less straightforward and more questionable sedimentary, morphologic, and other criteria, are reviewed in the following.

Berm Ridge Elevation and Crest Attitudes

STAPOR *et al.* (1991) correctly acknowledged wave energy and wave height as decisive factors that control beach ridge elevations and storm overwash processes, responsible for building 2.7 m high shelly beach ridges on La Costa Island, Florida during the past century. Eustatic sea level has risen only slightly in that time. There are no compelling reasons to invoke high (+0.9 to +2.7 m) sea levels, based on crest elevations of Late Holocene beach ridges alone. Pebble-sized shell clasts that occur at +3 m elevation in planar laminae of gentle seaward dip (DONOGHUE *et al.*, 1998, p. 672), thus may well reflect episodic high storm tide levels, rather than an assumed +3 m eustatic sea-level stand 1,600 years ago.

The Discussion's argument (p. 672) that 300 shell dates from the Lee County ridges prove the existence of late Holocene highstands can not be considered as valid. They may provide approximate maximum ridge ages but not ancient sea-level positions.

Unlike the "flat" high-tidal sandy berm mounds, the usually fairly steep relict foredune beach ridges *have substantial relief.* Their crest elevations do not translate into elevated Holocene sea-levels. These, and *not* the wave-built, usually buried, intertidal "berm ridges" form the surface topography of most Holocene Gulf strandplains.

Because of their supposedly intertidal origins, even-crested sand ridges have been said to mark previous Holocene record highstands (DONOGHUE *et. al.*, 1998, p. 672; MORTON *et al.*, 1997, p.A-218). MORTON *et al.* (1997) related maximum *3 m* high Holocene littoral ridges on the Texas Gulf coast to an assumed *+1 m* highstand stage, between 5.0-to-2.5 ka B.P. Given a steady sand supply and fairly homogeneous vegetative cover, relatively uniform ridge crests may not be unusual in active and relict foredune ridges.

Scarps and Terraces as Sea-Level Markers

STAPOR *et al.* (1991) and DONOGHUE *et al.* (1998) believed that widely occuring wave-cut terracettes, terraces and scarps formed during record Holocene highstands. They dismissed the possibility of terrace/scarp formation by storm surge erosion. Stapor asks: why did the scarp-terrace couples form exclusively on sheltered Pleistocene lagoonal shores and never in the exposed Holocene barriers? Why are their elevations restricted to the +1.5-to-2.0 m range?

Lagoonal shores (*e.g.*, Apalachicola Bay and Mississippi Sound) may also experience intensive storm erosion, little mitigated by intervening Holocene barriers or barrier islands (OTVOS, 1995, p.993). Breaking waves, associated with storm tides focus their erosive energy a few meters above normal sea-levels. Reasonably high terrace and scarp-toe elevations therefore would not be unexpected. The Holocene Gulf shores, composed of loose Holocene sand naturally experience more erosional scarping and storm terrace formation than the less active Pleistocene lagoonal bluffs. Storm terraces commonly form 1.5–2 m above normal tide levels on the Gulf sides of the islands.. On active Gulf shores, abundant littoral sand supply and associated wave/wind processes soon heal and cover such noted erosional features.

As earlier noted (OTVOS, 1995, p. 993), at least some of the scarp-terrace combinations may not be erosional. Not involving wave scarping, preexisting, relatively steep Pleistocene slopes, in combination with slopewash and eolian buildup in front of them may also create such a topography. One of STAPOR's (1975) examples for eustatic highstand terraces lies adjacent to the Pleistocene Gulfport barrier strandplain in the Pensacola Naval Base. Before construction of the Base, this surface used to be occupied by a Late Holocene dune ridge plane, with its base near present sea level. It is clearly unrelated to scarping during any hypothetical, eustatically induced previous highstand.

Indian Cultural Sites, Salt Marshes, and Oyster Reefs—New Evidence for Sea-Level Highstands?

Well-documented, archeologically dated Prehistoric cultural sites, associated with independently datable under- or overlying littoral deposits under favorable geological conditions along estuarine shores would serve as reliable evidence for higher-than-present Holocene sea levels. If formed during prolonged high sea-level stands, not by local wave-climate related episodic processes or perhaps even local uplift, associated deposits would be acceptable in this regard. Minor Late Holocene sea-level fluctuations certainly may have taken place. However, in the absence of datable sediment matter of identifiable origin, even the more recent midden evidence presented by Walker and her coworkers remains inconclusive. Local subsidence, due to compactable Holocene muds located beneath datable midden intervals may create the false impression of lower-than-actual ancient sea levels.

WALKER *et al.* (1995, p. 214–215) interpreted a 8-cm thick, fossil-free sandy clay bed as a transgressive intertidal marsh

deposit, signifying inundation of a midden at the Paradise Point cultural site on St. Vincent Island, NW Florida.The clay layer, at ca. 80 cm above present mean high tide, directly overlies an anthropogenic horizon. Plant fragments, that if *in-situ* would qualify it as a salt marsh deposit, were not described in the sandy clay bed. The exact nature of this stratum and the overlying fine-grained quartz sand unit, sandwiched between the Middle and Upper Midden intervals remains unknown.

Of significant interest is a 5-cm thick oyster-bearing unit in the Wightman Site on Sanibel Island, western Florida Peninsula. At ca. +40 cm above present MSL, it represents either the top cultural layer in the Lower Midden interval or, as interpreted by WALKER *et al.* (1994), a "contact zone" of juvenile oysters in *in-situ* position, deposited on the transgressed and drowned Lower Midden unit. The overwashed shelly quartz sand bed above the 5-cm clay layer, related to episodic storm inundations, did not necessarily form during an eustatic highstand stage either.

Finding several scattered, small clusters of diminutive *Crassostrea* bivalves in "life position", WALKER *et al.* (1995) interpreted the 5-cm interval as an incipient oyster bar (reef) on drowned midden surface between 460–619 cal yrs A.D. A sea-level rise to a minimum +70 cm above present MSL was inferred. However, before accepting even a localized highstand episode, further work must first prove that juveniles in life position are not attached to mature shells in proven oyster-rich midden intervals. One must also discount the possibly that the juvenile shells were transported by natural processes or anthropogenic means from surrounding water bodies.

"Mobile Bay" Midden Interval—Proof of Rising Sea Level?

DONOGHUE *et al.* (1998, p.672) mistakenly refer to my paper (OTVOS, 1995, p. 1000) as discussing "inundated middens *in Mobile Bay*". The locality is *not* in the Bay, but in the extensive floodplain, ca. 42 km upriver. Recurring stream flooding could easily have buried and preserved the cultural strata. There is nothing in the archeological data or what the Discussion states that proves recurring and prolonged eustatic Holocene highstands. Substantial barren intervals, sandwiched between cultural horizons do not necessarily represent periods of raised sea levels.

OTHER ISSUES

One major target of the cited Discussion was my contention (OTVOS, 1995, 1997) that, except for the Late Pleistocene shore complex, no provable Pliocene and Quaternary marine lithosomes, representatives of elevated shore zones, exist in the northeastern Gulf coastal plain.

Late Pliocene Deposits—Misapplication of Granulometric Statistics

The esoteric use of granulometric parameters, in isolation from depositional facies, geomorphic data and, indeed from fundamental geologic principles, resulted in rather peculiar claims (*e.g.,* DONOGHUE *et al.,* 1998, p. 670) for the alleged presence of relict barrier island, barrier, surf and/or intertidal facies in the Pliocene Citronelle (Miccosukee) sequence of NW Florida. Truncation points between plotted traction, saltation, and suspension populations in sandy alluvial (bar or channel?) lithosomes may well produce similarities with the granulometric populations of certain shore deposits.

Based on granulometric data alone, "moderate-to-high wave energy" conditions had been inferred automatically by authors of the Discussion. However, the samples in question were from continental and paralic, not marine littoral deposits. These gravelly and muddy sands, sands, and sandy muds were laid down in mostly fluvial lithofacies. The extensive character of an inshore (estuarine; bay/lagoonal?) Citronelle facies has been recognized recently (OTVOS, 1998).

Uplift of the Pliocene Coastal Uplands?

DONOGHUE *et al.* (1998, p. 670) denied that my quote on the continuing broad and slow uplift of the Citronelle uplands west of Florida was valid and state: "In reality Holdahl and Morrison's evidence shows that there is *no ongoing uplift* in the northeastern Gulf Coastal Plain". Preliminary geodetic data, however, indeed indicated that a broad uplift continues inland from the present Mississippi-Alabama shore. Releveling surveys and mareograph data suggested maximum *uplift* rates of 3-to-4 mm/yr.

The large-scale preliminary map of HOLDAHL and MORRISON (1974; Figure 5) does show slight subsidence along and south of the present Mississippi-Alabama coast. Restricted to the narrow *Pleistocene* shore zone, this zone widens eastward. The deeply incised drainage network of the northeast Gulf coastal *Citronelle uplands* indicates considerable uplift since Late Pliocene times along the entire northeastern Gulf coast (OTVOS, 1997, 1998).

Data from leveling surveys between 1934-to-1969 (JURKOWSKI *et al.*,1984, and BROWN, *pers. comm.,* 1998) provided further corroboration of the earlier findings. A broad doming of the Citronelle coastal plain surface took place between Jackson, Mississippi and north of New Orleans, Louisiana. The final results of the leveling surveys have not yet been made available.

A "Logging Train Ride" with Bill Tanner in Tates Hell

Two narrow, elongated surface zones, at ca.+6, respectively, + 9 m elevations, previously referred to as relict barrier islands have been described from the Tates Hell wetlands, east of the Apalachicola Delta (*e.g.,* MACNEIL, 1950, p.104; DONOGHUE *et al.,* 1998, p. 669–670, *etc.*). This literature provides glaring examples as to how far off course mechanical granulometric and map interpretation of depositional facies and landforms may lead. The ridge tops are almost flush with and blend into the surrounding Late Pleistocene Sangamonian (Prairie, previously "Pamlico") alluvial coastal plain surface. The continuous surface slopes evenly and gently very close to the present mainland shoreline. Despite this configuration, the two elongated landforms in the uniform surface were treated as two *separate* pre-Sangamonian "terraces" of

apparently different ages (DONOGHUE and TANNER, 1992; DONOGHUE *et al.,* 1998).

Lineaments, fracture networks, delineate the two zones restricted to the two elongated zones. Their orthogonal pattern, not restricted to these elongated parallel surface strips that rise slightly above the adjacent swampy ground is well displayed on aerial photos (OTVOS, 1995, Figures 3, 4). Joint fractures (*not* faults, that *do have* vertical displacement), contrary to the Discussion, could not recognized in corehole-based cross sections in the unconsolidated sediments. Shallow seismic surveys and/or a drillhole network, significantly more closely spaced than the previously drilled one (OTVOS, 1992), may well reveal "ridge"-bounding faults here in the future.

The two elongated zones are directly underlain by alluvial Prairie sands and muddy sands; their flat, dune-free strips of land in seaward and landward direction rise barely (ca 60-to-120 cm) over the surrounding Pleistocene coastal plain surface. These two zones are underlain. by moderately and poorly sorted alluvial Prairie Formation sands and silty sands and flanked by swampy, shallow covered karst depressions. No underlying marine or estuarine Pleistocene intervals had been encountered in the drillcores (OTVOS, 1992, 1995).

Quite apart from the lack of associated marine and lagoonal depositional units and well sorted sandy littoral lithofacies, it defies geological thinking as to how these two perfectly flat, low, merely 100-to-300 m wide and ca. 10 km long alleged "barrier islands" could have been maintained in the face of wave and then, fluvial erosion. Even if they survived regression intact, how could they have escaped burial by fluvial deposits at the end?

Tanner (in: DONOGHUE *et al.,* 1998) mistakenly ascribed two "tortured interpretations" of ridge formation to me. Clearly, I was *not* proposing *two alternate* modes of "ridge" development. Formation of the shallow (covered) karst depressions by solutions along preexisting tectonic lineaments (OTVOS, 1995) represented two sides of the same coin.

DONOGHUE *et al.* (1998, p.670), incorrectly, attributed yet another absurd notion to my paper. At great length, they ridicule the idea that these two elongated landforms were entirely man-made. My own text, however, reads: "Abandoned logging railroad embankments, located on these strips, *slightly enhanced* the ridge elevations" (OTVOS, 1995, p. 988).

Missing References to Tates Hell Swamp Ridges?

I was also chastised by DONOGHUE *et al.* (1998, p. 670) for ignoring earlier literature that supposedly provided overwhelming support for the island/barrier origins of the two elongated "ridge" features. A slightly more careful reading of my article would have shown otherwise.

With the *correct* year of publication and spelling (*not* as "MACNEILL, 1949"), I indeed did cite MACNEIL (1950), who started the erroneous interpretation of these features as littoral barriers and/or islands. DONOGHUE *et al.* (1998, p. 670) confuse Walt Schmidt's 1984 work with Schnable's dissertation. Schmidt's report, in fact, avoided any reference to these strips of ground. Not involved with the study of the two "ridges" either, Schnable also remains "blameless". From earlier papers he merely copied the "barrier island sand ridges" onto his reference map (SCHNABLE and GOODELL, 1968, Figure 2).

Contrary to what one would expect after reading DONOGHUE *et al.* (1998, p. 670), the cited soil survey makes *absolutely no mention* of the two ridge-like features as "relict barrier islands/ beach ridges", or otherwise (SASSER *et al.,* 1994). On the accompanying map sheets, these landforms are covered by a dozen "detailed soil map units", including six prominent ones (Units 2, 21, 27, 28, 32, 38 in Map Sheets 10, 16, 17). No significant lithologic contrast is indicated between the soil units. Not restricted to the two ridges, their identities were largely defined by topographic positions.

The "detailed soil units", mapped on the ridges formed on poorly drained, fine sandy grounds; slightly elevated, level or slightly inclined surfaces. A corresponding single sentence, under "Geomorphology" (SASSER *et al.,* 1994, p.3), simply repeats outdated old views concerning "relict bars and spits which formed at higher sea level stands" in the County's interior.

In yet another misquote, DONOGHUE *et al.* (p. 670) cite MAXWELL's (1971) ionium disequilibrium dates as supposed indicators of pre-Sangamonian (pre-Prairie/Pamlico floodplain)—ages of the two alleged relict Tates Hell "barrier islands". While *nothing* to do with Tates Hell's so-called "terraces", the U/Th dates actually came from Alabama River terraces in Alabama.

Pliocene Marine Terraces in Northwestern Florida?

When claiming beach ridges and "well-known cuspate (littoral) forelands", between +35 to 80 m elevations (DONOGHUE and TANNER, 1992; OTVOS, 1995, Figure 1), DONOGHUE *et al.* (1998, p. 670) merely repeat previous assumptions, based exclusively on the less than credible speculations based on granulometric data (OTVOS, 1995) and the broadly parallel pattern of Chipola and Apalachicola River tributaries. Neither this area's lithology, nor the large vertical and horizontal dimensions of the interfluve ridges and their configurations suggest lithological and/or geomorphic similarities with (wave-built) barrier spits.

Field work and sediment studies demonstrate that these 20 to 30 m high, broad, erosionally sculpted interfluve ridges consist not of marine coastal lithosomes, but the widespread Late Pliocene Citronelle Formation (OTVOS, 1998).

The Role of Tectonic Lineaments in the Coastal Plain

Ample evidence to the contrary (*e.g.,* OTVOS, 1981), the Discussion rejects the tectonic nature of fractures, scarps, and other lineaments in the northeast Gulf Pliocene-Pleistocene coastal plain and their role in the plain's morphology. In a somewhat absurd fashion, the authors compare the continuity, linearity, and fresh appearance of Gulfward scarps and other lineaments cut into poorly sorted, gravelly and muddy-sandy Citronelle and Pleistocene alluvial deposits, with Holocene *littoral beach ridge and beach lithosomes* that posses a "similarly non-tectonic" linearity.

Regional Comparisons Between Neogene and Quaternary Sequences

Quite puzzling are the grounds on which the Discussion complains about the comparison of the "Mississippi River coast"(?) with that of "north" Florida—"two sedimentologically disparate coastal regions . . . with substantial differences" (DONOGHUE *et al.,* 1998, p. 669). Contrary to what the Discussion states, my regional comparison of Neogene and younger units *did not in the slightest* involve the subsiding Holocene Mississippi Delta complex of Louisiana.

That statement on the significant stratigraphic contrasts and the correlation that, according to the Discussion, "must therefore be considered tenuous", were based on several well-reasoned publications from Mississippi, Alabama and northwest Florida. As noted before, Donoghue and his coauthors were unaware that the Quaternary subsidence-impacted fringe zone along the southeast Louisiana border and a minor ongoing subsidence along the present shore (OTVOS, 1995, 1997) notwithstanding, the Mississippi-Alabama coastal uplands have *not* been subsiding.

The lithologic and depositional facies contrasts between the siliciclastic Middle, Late Miocene, and Lower Pliocene sequences in southeast Louisiana and the western Florida Panhandle and the carbonate-enriched units, in the east, have long been known. In contrast, the lithology, fossil content, and other aspects of the Citronelle and the Late Pleistocene Biloxi, Prairie, and Gulfport Formations along the northeastern Gulf shore zone are rather uniform (OTVOS, 1997).

LITERATURE CITED

BALSILLIE, J.H. (Compiler), 1995. Wm. F. Tanner on Environmental Clastic Granulometry. *Florida Geological Survey Special Publication,* No. 40, 142 p.

DONOGHUE, J.F. and TANNER, W.F., 1992. Quaternary terraces and shorelines of the Panhandle Florida region. *SEPM Special Publications* 48, pp.233–241.

DONOGHUE, J.F.; STAPOR, F.W., and TANNER, W.F., 1998. Discussion of: Otvos, E. G., 1995. Multiple Pliocene-Quaternary marine highstands, northeast Gulf coastal plain—fallacies and facts. *Journal of Coastal Research,* 11, 984–1002. *Journal of Coastal Research,* 14, 669–674.

FRIEDMAN, G.M., 1961. Distinction between dune, beach, and river sands from their textural characteristics. *Journal of Sedimentary Petrology,* 31, 514–529.

JURKOWSKI, G.; NI, J., and BROWN, L., 1984. Modern uparching of the Gulf Coastal Plain. *Geophysical Research,* 89(B7), 6247–6255.

MACNEIL, F.S., 1950. Pleistocene shore lines in Florida and Georgia. *U.S. Geological Survey Professional Paper* 221-F, pp. 95–107.

MASON, C.C. and FOLK, R.L., 1958. *Journal of Sedimentary Petrology,* 28, 211–226.

MASON, O.K.; HOPKINS, D.M., and PLUG, L., 1997. Chronology and paleoclimate of storm-induced erosion and episodic dune growth across Cape Espenberg Spit, Alaska, USA. *Journal of Coastal Research,* l3, 770–797.

MAXWELL , R.W., 1971. Origin and chronology of Alabama River terraces. *Transactions Gulf Coast Association of Geological Societies,* 21, 83–95.

MORTON, R.A.; PAINE, J.G., and BLUM, M.D., 1997. Morphological evidence of mid-Holocene highstand in sea level along the Texas coast. *Geological Society of America Abstracts with Programs,* A-218.

OTVOS, E.G., 1981. Tectonic lineament of Pliocene and Quateranry shorelines, northeast Gulf coast. *Geology,* 9, 398–404.

OTVOS, E.G., 1992. Quaternary evolution of the Apalachicola coast, northeastern Gulf of Mexico. *In:* Wehmiller, J.F. and Fletcher, C.H., (eds.), Quaternary Coasts of the United States: Marine and Lacustrine Systems, *SEPM Special Publication* 48. Tulsa: Society for Sedimentary Geology, pp. 211–232.

OTVOS, E.G., 1995. Multiple Pliocene-Quaternary marine highstands, northeast Gulf coastal plain-fallacies and facts. *Journal of Coastal Research,* 11, 984–1002.

OTVOS, E.G., 1997. Northeastern Gulf Coastal Plain Revisited. Neogene and Quaternary Units and Events—Old and New Concepts. *Guidebook,* New Orleans Geological Society, 143 p.

OTVOS, E.G., 1998. The Gulf coastal Pliocene Citronelle Formation; definition, depositional facies, and age issue. *Transactions Gulf Coast Association of Geological Societies,* 48, 321–333.

RUZ, M.-H. and ALLARD, M., 1995. Sedimentary structures of cold-climate coastal dunes, eastern Hudson Bay, Canada. *Sedimentology,* 42, 725–734.

SASSER, L.D.; MONROE, K.L., and SCHUSTER, J.N., 1994. Soil Survey of Franklin County, Florida. *US Department of Agriculture, Soil Conservation Service,* 189p., with 45 map sheets.

SCHNABLE, J.E. and GOODELL, H.G., 1968. Pleistocene-Recent Stratigraphy, Evolution, and Development of the Apalachicola Coast, Florida. *Geological Society of America Special Paper,* 112, 72p.

STAPOR, F.W., JR.,1975. Holocene beach ridge plain development, northwest Florida. *Zeitschrift f. Geomorphologie,* Supplementband, 22, 116–144.

STAPOR, F.W., JR., and OTHERS. 1991. Barrier island progradation and Holocene sea-level history in southwest Florida. *Journal of Coastal Research, 7,* 815–838.

VISHER, G.S., 1969, Grain size distribution and depositional process. *Journal of Sedimentary Petrology,* 39, 1074–1106.

WALKER, K. J.; STAPOR, F. W., JR., and MARQUARDT, W.H. 1994. Episodic sea levels and human occupation at southwest Florida's Wightman Site. *Florida Anthropologist,* 47, 161–179.

WALKER, K.J.; STAPOR, F.W., JR., and MARQUARDT, W.H., 1995. Archaeological evidence for a 1750–1450 BP higher-than-present sea level along Florida's Gulf coast. *In:* FINKL, C.W., Jr., (ed.), *Journal of Coastal Research Special Issue,* No. 17:Holocene Cycles: Climate, Sea Level and Sedimentation, pp. 205–218.