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Geomorphology and Stratigraphy of the Paleolithic Site of Budiño

(Prov. Pontevedra, Spain)

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With 13 figures

Zusammenfassung. Die paläolithische Freilandstation Budiño liegt im Lourotal, Süd-west-Galizien (Spanien), und wurde 1963 von E. DE AGUIRRE teilweise ausgegraben. Die Werkstätten und vermutlichen Lagerplätze weisen eine Vielfalt von Steintechniken und Artefaktentypen auf, die in ungestörter Assoziierung und geologischer Lagerung gefunden wurden. Aus Quarzit und Quarz hergestellt, enthält das Werkzeuginventar Haugeräte, dreiseitige Hacken, sogenannte Camposancos-Hacken, clactonartige Abschläge und Kerbstücke, Proto-Faustkeile, gezahlte Stücke und andere Abschlagswerkzeuge. Trotz der starken morphologischen Beziehungen zum Camposanquien (oder Languedocien) einerseits, zum Asturiense andererseits, deuten die geologischen Verhältnisse und Radiokarbonbestimmungen auf ein Mittelwürm-Alter.

Die Täler des niederen Miño und des Louro weisen einen Hochterrassenkomplex (+76/80 m, 65/68 m, 52/59 m), zwei Mittelterrassen (+42/44 m, 34/36 m), Nieder- (+22/24 m) und Überschwemmungsterrassen (+3/10 m) auf. Da Hinweise auf Kryoturbation oder Frostsprengung in den Terrassenbildungen fehlen, wurden sie wohl unter warmzeitlichen Bedingungen aufgeschottert, hauptsächlich als Auswirkung verschiedener hoher Meeresspiegelstände. Die oberste Mittelterrasse ist unmittelbar mit einer 44/49 m Strandterrasse der Atlantikküste verknüpft, während die untere Mittel- sowie die Niederterrasse wahrscheinlich mit Strandniveaus von +33/36 m bzw. +23/24 m zu parallelisieren sind. Die Überschwemmungsterrasse ist Postglazial, zeigt ein steileres Gefälle als die pleistozänen Terrassen und könnte der Entwaldung und Bodenerosion zuzuschreiben sein. Die Oberfläche des Hochterrassenkomplexes (Altpleistozän?) ist stark verwittert und von einer Rotlehmdecke überzogen. Entsprechende Meeresspiegelstände sind an der Küste nicht nachzuweisen. Das Alter der Mittelterrasse (mit Hinweisen auf rote Paläoböden) und Niederterrasse (ohne Paläoböden) ist unsicher (Mittelpleistozän?).

Kleintektonik, Flußeinschneidung sowie niedrige Strandausbildungen in +10/12 m, +6/7 m und +2,5 m sind insgesamt zwischen der Niederterrasse und den jungpleistozänen Ablagerungen einzuschalten. Drei stratigraphische Einheiten können auf Grund des geologischen Befundes und der Radiokarbonbestimmungen unterschieden werden: die Mougás-Schichten (Frühwürm, älter wie 40 000 J.), die Sanjián-Schichten (Mittelwürm, ca. 28 000—16 000 v. H.), und die La Guardia-Schichten (Spätwürm). Normalerweise geht jede vertikale Schichtfolge von einem organischen Kolluvium, das vermutlich von Tangelranker-Paläoböden zusammengeschwemmt wurde, in Hangschuttdecken, Schwemmfächern oder -kegel über. Da Frostsprengung, kryoturbate Störungen sowie andere periglaziale Lagerungserscheinungen nicht festzustellen sind, können diese grobkörnigen Aufschüttungen der Flächenspülung und dem Gekriech zugeschrieben werden.

Die Fundstelle Budiño ist gleichaltrig mit den Sanjián-Schichten und datiert aus der Zeit zunehmender Kälte, die dem „Paudorf"-Farmdale Interstadial folgte.

Summary. The Paleolithic site of Budiño, located in the Louro Valley of southwestern Galicia, was partly excavated by E. DE AGUIRRE in 1963. The occupation floors include flaking and possible habitation sites with a great variety of tool-making techniques and tooltypes found in undisturbed associations, geologically *in situ*. With quartzite and quartz as exclusive raw material the artifacts include choppers and chopper-tools, trihedral picks, so-called Camposanquian picks, Clactonian flakes and notches, proto-bifaces, denticulates and other flake tools. Despite strong morphological similarities to collections known as Camposanquian (or Languedocian) on the one hand, Asturian on the other, the geomorphological evidence and radiocarbon dates indicate a Middle Würm age for the period of prehistoric occupation.

The Louro and lower Miño valleys exhibit a High Terrace complex (+76/80 m, 65/68 m, 52/59 m), two Middle Terraces (+42/44 m, 34/36 m), a Low (+22/24 m) and a Floodplain Terrace (+3/10 m). Lacking evidence of cryoturbation or congelifraction these terraces in general appear to record non-glacial paleoclimates, primarily aggraded in response to base-level stimuli. Thus the upper Middle Terrace is linked directly to a marine shoreline at +44/49 m; the lower Middle and the Low Terraces are probably contemporary with shorelines at +33/36 m and +23/24 m respectively. The Floodplain Terrace is Holocene, has a steeper gradiant than the Pleistocene gravel terraces, and is attributed to accelerated run-off in historical times. There are no marine

platforms corresponding to the High Terrace complex, which is covered by deep Rotlehm paleosols and thougth to be early Pleistocene. The Middle Terraces, with some evidence for reddish paleosols, and the Low Terrace, with no record of paleosols, are of uncertain age, presumably Middle Pleistocene.

Minor tectonic displacements, stream dissection, and a number of lower shorelines at +10/12 m, +6/7 m, and +2.5 m all intervene between the Low Terrace and deposition of the late Pleistocene sequence. Three units are recognized on stratigraphic and radiocarbon criteria: the Mougás beds (Early Würm, older than 40,000 yr), the Sanjián beds (Middle Würm, ca. 28,000—16,000 B. P.), and the La Guardia beds (Late Würm). Typically each unit ranges upwards from a colluvium of detrital organic matter, probably derived from Tangel-Ranker paleosols, to colluvial sheets and alluvial fans or cones. Since congelifraction and periglacial bedding are absent, these coarse mineral deposits are attributed to accelerated runoff, sheetwash and creep.

The Budiño site is contemporary with the Sanjián beds, and dates from the period of increasing cold following the „Paudorf"-Farmdale interstadial.

Introduction

Paleolithic tools were first reported from the lower Miño valley, along the Portuguese-Spanish border, in 1920. In subsequent years a great number of surface collections were made, and a stratigraphic scheme of industries described, solely on the basis of typology

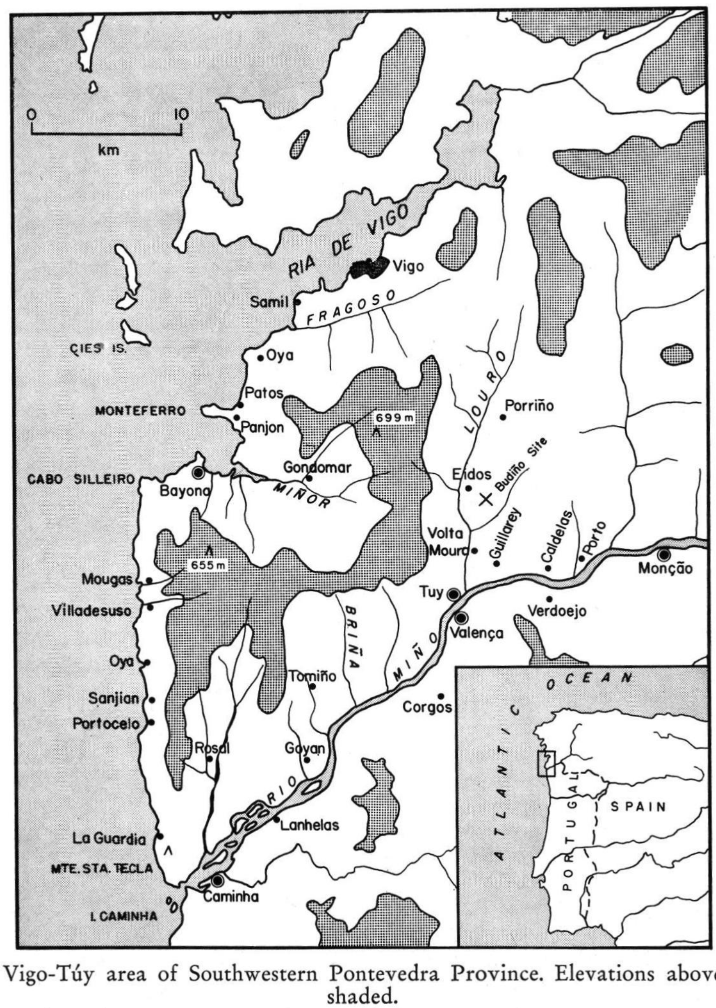

Fig. 1. The Vigo-Túy area of Southwestern Pontevedra Province. Elevations above 400 meters shaded.

and patina of individual artifacts, rather than of assemblages (see ALVAREZ-BLASQUEZ & BOUZA-BREY, 1949; BOUZA-BREY & ALVAREZ-BLASQUEZ, 1952). Thus several stages of Acheulian were claimed to exist here, together with industries of Middle Paleolithic (Camposanquian) and Epi-Paleolithic (Asturian) affinities. In many instances when different types of tools were found together the more "primitive" artifacts were considered to be "derived". All of the Miño valley collections were made from quarzite, one of several traits shared with most of the Portuguese Paleolithic (see BREUIL & ZBYSZEWSKI, 1945).

In 1961 a new surface collection of some 200 artifacts was made from the spoil heaps of a kaolin quarry near Budiño, in the Louro valley, a tributary of the Miño (Fig. 1). The tools included a combination of archaic picks, some of Camposanquian type, proto-bifaces and cores, all worked in quartzite or quartz (AGUIRRE, 1964). Consequently, after preliminary inspection of the area in 1962, an excavation was organized under the direction of Dr. EMILIANO DE AGUIRRE and with the support of the Wenner-Gren Foundation. A complex of occupation floors was found geologically *in situ* during the course of the excavations (July-August 1963) at a locality just east of Km 20.0 of the highway Vigo-Túy, near Km 99.8 of the railroad Monforte-Vigo. Some 16 trenches with a total area of 191 square meters were opened, and archeological materials methodically recorded and removed. These excavations have been described, together with archeological sections and a preliminary analysis of the artifacts, by AGUIRRE (1964). The following paper attempts to outline the geomorphological setting of this Paleolithic occupation site within a regional Pleistocene context.

The Regional Physical Setting

Southwestern Galicia is dominated by remnants of a high erosional surface at 450—650 m elevation (see Fig. 1), formed by a complex of intricately fractured and frequently intruded crystalline rocks. Precambrian granite gneiss, migmatitic granite, schist and gneiss are all intruded by dykes and veins of pegmatitic quartz or batholithic masses of granite porphyry, primarily of Paleozoic age (LÓPEZ et al., 1953, 1956). Dissection of this ancient mass has been preconditioned by two major fault systems, one striking N to N 15° W (related to the Louro valley and the poorly articulated linear coast south of Cibo Silleiro), the orther striking N 60—80° E (related to the valleys of the Miño, Miñor and Foz or Fragoso). Apart from the gross, tectono-erosional aspects to the landscape, topographic details can be attributed to dykes, minor fault zones, contacts between different lithologies, and differential resistance in general.

Planation of the Galician upland surface appears to have terminated at the close of the Oligocene, and lacustrine beds rich in fibrous clay minerals were first deposited in the incipient valleys during Aquitanian times (LUCAS et al., 1963). Subsequently old fault lines were reactivated, while massive clays formed or accumulated in a number of localized basins. These clays, consisting primarily of kaolinite, extend to below modern sea-level in the Louro and Briña valleys, and at Panjón. They are usually stratified in massive beds with a variable admixture of fine to coarse quartz detritus. This suggests subaqueous deposition of alteration products derived from a deep weathering mantle on the slopes. Abundant macroremains of arboreal gymnosperms and palms (identified by E. DE AGUIRRE) were found within an intercalated peaty stratum near Budiño (Miña Rogelita), and NONN & MÉDUS (1963) describe a Tortonian or Tortono-Pontian flora (on palynological grounds) from similar deposits in northern Galicia.

Thus the broad lines of the physical landscape had been established by the close of the Tertiary. During Pleistocene times a number of fluvial platforms or gravel terraces were developed in the major river valleys, while marine benches were cut along the coasts. Meanwhile the great drowned, tectono-erosional *rias* of western Galicia continued to evolve in the wake of alternating eustatic regressions and transgressions (Nonn, 1958; Mensching, 1961; Pannekoek, 1966).

Today the southwestern part of Pontevedra Province enjoys a temperate climate, with January mean temperatures of 46—48° F (8—9° C) and July means of 66—68° F (19—20° C) (see Lautensach, 1964: Maps 4—5; Hydrographic Office, 1963: 348—49). Mean monthly minimum temperatures in January lie between 38 and 42° F (3.5—5.5° C), and although severe frosts occur periodically, frost-weathering as such is not very effective. On the average, August alone is arid by the Thornthwaite system (Lautensach, 1964: Map 8) and the area lies athwart the boundary between Koeppen's summer-dry *(Csb)* and permanently-moist *(Cfb)* climates. Rainfall is at a maximum in December, and annual totals average from 1100 to 1600 mm, increasing from the coastal lowlands to the high country (Lautensach, 1964: Map 6).

In relation to the silicate bedrock and contemporary climate, climax soil development under "average" conditions of slope and parent material tends toward a Meridional Braunerde, although few intact profiles are preserved. However, Rotlehm paleosols are widespread on early to middle Pleistocene surfaces, and deforestation of the uplands has favored the spread of acidophile ericaceous heaths, with accociated podsolic Rankers or Braunerdes. Lithosols are characteristic of most slopes over 15—20°. Whereas the native Holocene vegetation of Galicia is believed to have been a mixed deciduous oak woodland (see Lautensach, 1941, 1964: 308), deciduous species, including *Quercus, Castanea, Acer, Ulmus, Fraxinus, Populus* and *Alnus,* are now almost restricted to the low terraces and floodplains of the river valleys. The Middle and High Terraces, as well as many slopes, are stocked with *Pinus maritima (= pinaster),* although heaths of *Erica* and *Ulex* are widepread, either as un understorey to the pine woodland or as a dominant community.

The Setting of the Budiño Site in the Middle Louro Valley

Remnants of several Pleistocene terraces are found in the middle Louro valley (Fig. 2). A high terrace at 67 m (absolute elevation, or 53 m above local floodplain) includes over 45 m of coarse quartz and granitic gravel. A lower substage of the same terrace at 56 m elevation includes some 10 m of similar local materials: 46% of pegmatitic quartz, 3% metamorphosed quartz with granitoid structure, 51% pink meta-granite. There is a considerable component of angular detritus, and rounding is limited. But pebbles mechanically fractured during or after transport are few (6%), precluding significant congelifraction. A strong, red (2.5 YR 5/6) paleosol with a (B)-horizon over 1.5 m deep is developed on the surface of the High Terrace complex. Depending on the abundance of quartz grit in the parent material, texture varies from coarse-sandy clay to clayey coarse sand. The X-ray diffractogram of clay minerals shows significant peaks of gibbsite and kaolinite, while illite, vermiculite and hematite are also indicated. This Rotlehm paleosol (in the sense of Kubiena, 1953: 273—76; 1954) records a former period of intensive chemical weathering.

The Middle Terrace is recorded by a widespread platform, at 32—33 m absolute elevation, with local spreads or pockets of subrounded, medium-grade quartz gravel (86% pegmatitic quartz, 12% granitoid quartz, 2% pink meta-granite) or gravelly, cross-bedded sands (see also Fig. 7). Deposits exceed 6 m in thickness, but denudation has destroyed the paleosol. However surface gravels are locally ferricreted by a red (2.5 YR 4/6) clayey matrix, indicating a former abundance for free ferric oxides under conditions of fairly intensive weathering.

The Low Terrace is a body of current-bedded sandy grit and subangular, medium gravel (68% pegmatitic and 32% granitoid quartz) at 24 m elevation, about 10 m above

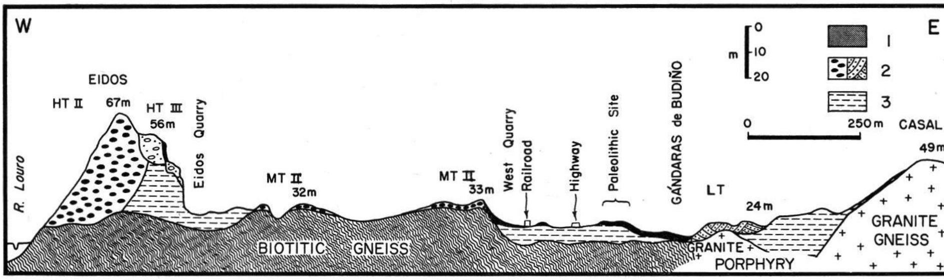

Fig. 2. Section of middle Louro Valley at the Budiño Site (Km 20 of the Vigo-Túy highway). 1 = Late Pleistocene colluvium; 2 = High (HT), Middle (MT) and Low (LT) gravel terraces of early to late Pleistocene; 3 = Mio-Pliocene kaolin and grit beds. All diagrams after detailed hand-level transects or line-level sections.

Louro floodplain. As in the case of the Middle Terrace, pebbles mechanically fractured during or after transport account for only 4% of the samples. Maximum thickness exceeds 5 m. There is no evidence for paleosol horizons, but this alluvium was micro-faulted prior to deposition of the next-youngest Pleistocene sediments.

The middle Louro sequence is terminated by two generations of colluvium that locally mantle the Middle and Low Terraces. The Lower Colluvium thickens downslope from 20—30 cm to 1.5 m, while the Upper Colluvium, confined to the valley bottoms, attains a thickness of over 1.3 m. Despite an erosional disconformity, there is no evidence of intervening soil development. The Lower Colluvium is coarser than the Upper, with a gravelly base and otherwise sandy-gritty texture with evidence of bedding and sorting. The pebbles are of coarse grade and subangular, with 86% pegmatitic and 14% granitoid quartz. Again only 6% are naturally fractured. The Budiño Paleolithic site is situated within this Lower Colluvium, with scattered artifacts occurring at almost all levels, but with the occupation floors concentrated in the lower half or along the disconformity between the two colluvial beds. The Upper Colluvium is a homogeneous, weakly stratified, silty coarse sand. The Holocene soil zone developed on the two colluvia is a dark to very dark brown or grayish brown A_0/A_1-horizon with mulliform moder humus, 25 to 90 cm thick. Although there is no B-horizon over Tertiary kaolin outcrops or on the finer grained colluvium, a very weak light yellowish brown to pink (B)-horizon of 20—60 cm is present in the permeable Lower Colluvium. There may also be some evidence of pseudo-gley conditions in the form of limonitic bands near base of solum. Transitional A/C or A/(B)-horizons of about 10 cm thickness are common, and occasionally there may be a slightly eluviated A_2, although clay skins are absent in the subsoil. pH of the A-horizons ranges from 4.5 to 5.1, the (B)-horizons 5.1—5.6. The soil type consequently alternates between a Meridional Braunerde and a Mulliform Ranker (see KUBIENA, 1953: 203), depending on parent material. The modern vegetation is a degraded, ericaceous heath, locally known as "Las Gándaras". In the nutrient-poor, sandy parent material of the Low Terrace and particularly over the dense kaolin beds this heath probably represents a spontaneous growth, whereas planted pine woodlands are found on the higher terraces and wherever the colluvia are well-drained and of greater thickness.

Micro-Stratigraphy of the Budiño Site

The Paleolithic site at Budiño is found within the Lower Colluvium as preserved upon a platform of the Low Terrace in 22.5—24 m (8.5—10 m above Louro floodplain). The micro-stratigraphy is illustrated by Figs. 3—5 and summarized by the sediment data of Tables 1 and 2:

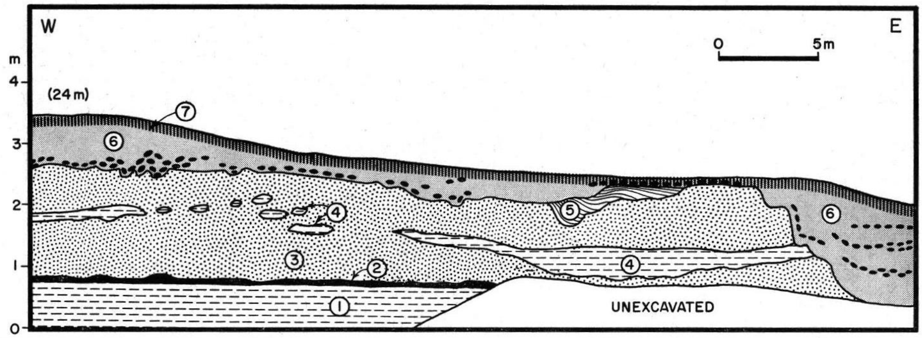

Fig. 3. Long Trench Section of the Budiño Site (Locality 2, South Face). Symbols explained in text.

(1) Over 75 cm. Intensively mottled (white, yellow, light red) residual clay with angular coarse blocky to prismatic structure. Laminations as well as fragments of decomposed, hematite-stained gneiss indicate redeposition. The X-ray diffractogram is dominated by very intense and prominent first and second-order kaolinite peaks, with a very weak but nonetheless distinct feldspar peak.

(2) 15—20 cm. Limonitic zone (yellow, some light red) developed at base of bed (3a), due to waterlogging over impermeable base. The hydrated ferric cement marks an incipient bog-iron zone.

(3) (lower part: 3a) 100—120 cm. Pinkish white, coarse-sandy gravel with some current-bedding. Bands of limonitic staining with some mottling due to seasonal waterlogging.

(3) (upper part: 3b) 30—80 cm. Very pale brown sediment as (3a). The overlying disconformity terminates the detrital kaolin beds, all presumably of Mio-Pliocene age.

(4) 0—35 m. White sandy clay with very coarse blocky to prismatic structure and limonitic staining of ped faces. Some derived(?), ferruginized quartz grains. The X-ray diffractogram is quite similar to that of bed (1).

(5) 0—60 cm. Very pale brown, current-bedded, sandy-fine gravel, with traces of biotite and muscovite as well as ferruginized quartz grains. Forms part of Low Terrace alluvium. Disconformity.

(6) (Lower Colluvium, gravelly base: a). 10—15 cm. Pale brown gritty coarse sand as matrix to subangular, coarse gravel. Stratified with turbulence pockets. Thickens to over 125 cm within channel previously cut into Low Terrace.

(6) (Lower Colluvium, finer upper part: b). 30—50 cm. Light yellowish brown, silty coarse sand with concentrations of quartz grit and medium-grade gravel, as well as traces of muscovite. Stratified perpendicular to valley axis.

(6) (Upper Colluvium: c). 0—125 cm. Very pale brown, stratified silty coarse sand with subangular medium blocky structure.

(7) 25—30 cm. Highly humic, very dark brown, gravelly coarse sand with medium crumb structure. A-horizon of Holocene soil zone as developed in units 6a, 6b and 6c.

Table 1

Grain Size Analyses of Strata at the Paleolithic Site of Budiño

Bed	2000-6400	595-2000	210-595	63-210	20-63	6-20	2-6	Under 2 microns
C-IX P:								
6c	6.5	17.4	20.2	13.4	14.5	7.0	3.5	17.5
6a	44.3	22.3	14.4	7.0	3.0	2.5	1.5	5.0
Long Trench:								
7	20.4	26.1	15.7	11.3	11.0	3.0	1.5	11.0
6b	12.0	19.3	21.3	13.9	12.0	5.0	2.5	14.0
6a	37.6	19.0	13.8	7.0	6.5	3.0	1.0	12.0
5	45.6	25.1	9.8	4.5	3.5	1.0	1.5	9.0
3b	49.4	22.2	8.0	2.4	2.0	1.0	2.5	12.5
4	3.1	14.9	8.5	6.3	7.0	11.0	5.5	44.5
3a	50.5	17.0	6.9	3.1	4.5	3.0	2.0	13.0
1	—	—	0.1	0.4	11.0	22.5	10.5	55.5

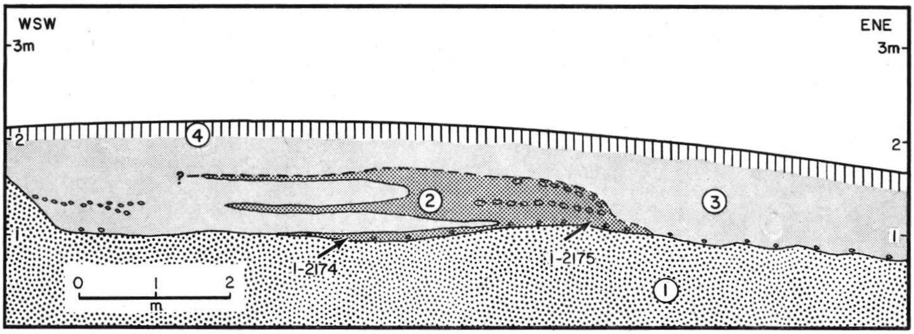

Fig. 4. Section of Trench C-IX P (Locality 2). 1 = Tertiary detrital Kaolin; 2 = Lower Colluvium, with grit-gravel (dark) and sandy (light) facies; 3 = Upper Colluvium (bed 6c of text); 4 = A-horizon of Holocene soil. I-2174 and I-2175 localize hearths from which radiocarbon samples were extracted.

The excavated archeological remains of the Budiño Site are confined to 651 artifacts and 56 larger stones with possible or certain evidence of working (AGUIRRE, 1964). In addition over 250 artifacts have been collected from the surface since 1961. The *in situ* artifacts are commonly found as concentrated flaking sites, and in at least one cut there were two vertically distinct levels. In trench C-IV P some 100 artifacts were found on a surface of less than 1.5 sq. m., lying amid some 80 quartz pebbles and associated with a quartz boulder clearly used as an anvil (Fig. 6) (AGUIRRE, 1964). Some implements of this association are in mint condition, obviously forming part of a workshop. Other associations may have represented kill or butchering sites, but the acidic soil environment has preserved no trace of bone. Only those artifacts found on the bank of the former channel once cut into the Low Terrace (Figs. 3—5) show some evidence of derivation. But there are several concentrations of charcoal, carbonized vegetable matter and a little ash, indicating a number of hearths just below the 1-meter bank once formed by the edge of the Low Terrace.

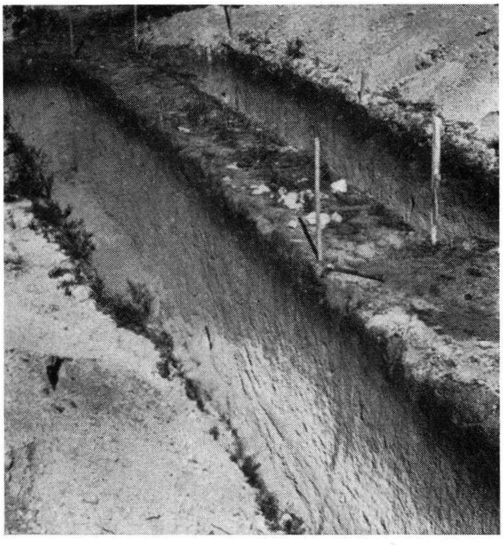

Fig. 5. Trench C-IX P (Locality 2), facing east. Below the dark A-horizon the Upper (medium gray) can be distinguished from the Lower Colluvium (light gray).

Fig. 6. Workshop floor exposed in Trench C-IVP (Locality), with artifacts and flaking debris scattered around quartz anvil. Photo by E. de Aguirre.

A remarkable variety of tool-making techniques and tool-types were found in undisturbed associations, with both archaic and apparently more evolved forms represented. The artifact inventory includes choppers and chopping-tools, trihedral picks, so-called Camposanquian picks, Clactonian flakes and notches, proto-bifaces, denticulates, and several other flake tools (see Aguirre, 1964: Pl. 5—12). Yet these flaking associations are in almost all cases physically homogeneous, undisturbed and not derived, either in the geological or archeological sense. And there is no question that these are occupation sites of a single cultural complex, probably recording repeated temporary occupation of a moderately restricted site area by prehistoric groups.

Wherever the gravelly basal unit of the Lower Colluvium (6a) is poorly developed, quartzite forms the primary or exclusive raw material. However, where natural, coarse-grade pebbles of quartz are abundant, these were commonly utilized for a variety of artifactual purposes (Aguirre, 1964). According to the provisional count, 58% of the 707 excavated artifacts consist of such local quartz pebbles, which correspond very closely in basic morphometry with the undisturbed gravels measured from other exposures of the Lower Colluvium. The remaining 42% of the artifacts were made in quartzite, which is absent in the Louro drainage and must have been carried in from the Miño valley.

Two radiocarbon determinations were obtained from hearths exposed in trench C-IX P (see Figs. 4—5). Sample I-2174 consisted of several adjacent charcoal fragments and carbonized wood resting on the disconformity between the Tertiary kaolin beds and the basal gravel of the Lower Colluvium. Sample I-2175 was a mixture of fine charcoal and carbonized vegetable matter in a sandy matrix, found about 10 cm. above the disconformity, coming either from unit 6 a or 6 b. Both samples were pretreated with Na OH and H Cl.

The results:

I - 2174	26,700 $^{+3600}_{-2500}$ B.P.		(24,750 B.C.)
I - 2175	18,000 ± 300 B.P.		(16,050 B.C.)

In terms of material I - 2174 was more suitable than I - 2175, altough the sample was smaller. Even if sample I-2175 represents bed (6b), it seems very unlikely that a hiatus of 8 millenia marks the occupational record. However three further C^{14} determinations from Würm-age deposits on the coast (see below) indicate that the broad time interval itself is correct, namely that the Lower Colluvium post-dates a warmer interval (Paudorf or Farmdale?), and was deposited during the early part of a cold period with accelerated geomorphic activity (Main or Middle Würm-Wisconsin).

The Long Trench section of the Budiño site is essentially repeated in the West Quarry, north-facing wall (Fig. 7, Table 3). Beds (2)—(6) are close counterparts for units (1)—(4) at the Budiño Site. Bed (8) corresponds to units (6a) and (6b), the Lower Colluvium, while (9) marks the A-horizon of the Holocene soil. Two aspects of the West Quarry section call for further comment. Bed (7) marks a complex 6-meter pothole-fill of the Middle Terrace. It includes clayey lenses, rich in decomposed gneiss fragments and biotite. The uppermost beds include cross-bedded grits, charged with secondary limonite, and embedding some muscovite and fragments of derived clay. Bed (1) refers to deeply weathered brownish-yellow to dusky red gneiss bedrock from which local bed (2) as well as unit (1) at the Budiño site are derived. Feldspars have been largely reduced to kaolin and hematite, leaving a residue of clay, quartz sand and mica grains, marking the BC-horizon of a former deep Rotlehm of Tertiary age. Derived residual products may be traced downslope to bed (2). A similar sequence can be observed 100 m further north along the east-facing wall (Table 3).

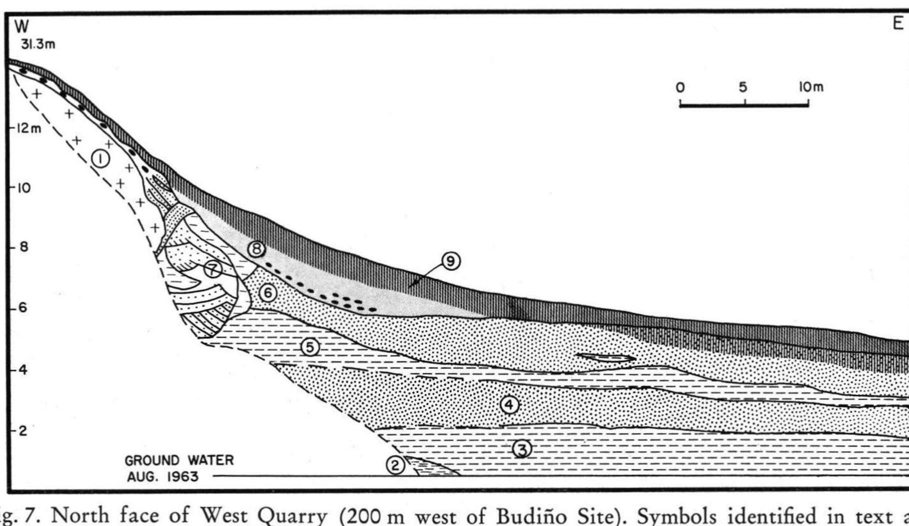

Fig. 7. North face of West Quarry (200 m west of Budiño Site). Symbols identified in text and Table 3. Patterns identical to those of Fig. 3.

Although the internal stratigraphy of the middle Louro valley is accordingly well-established, with two radiocarbon dates to fix the occupation floors of the Lower Colluvium in the early Middle Würm, a more complete stratigraphic framework must be obtained externally. This is provided by the terrace sequence of the lower Miño and by the marine abrasional forms of the coast between the Miño estuary and the Ria de Vigo.

Table 2

Sedimentology of Strata at the Paleolithic Site of Budiño
(Textural classes after WENTWORTH system)

Bed	Munsell Color (dry)	Textural Class	Percent Ca CO_3	pH(H_2O)
6c	10 YR 7/3	Silty coarse sand	0.3	4.9
6a	7.5 YR 8/4	Coarse-sandy gravel	3.5	5.3
7	10 YR 2/2	Gravelly coarse sand	0.0	4.75
6b	7.5—10 YR 6/4	Silty coarse sand	0.6	5.3
6a	10 YR 6/3	Gravelly coarse sand	0.4	5.15
5	10 YR 7/3—4	Coarse-sandy gravel	0.3	4.6
3b	10 YR 7/4	Coarse-sandy gravel	0.0	4.75
4	5 YR 8/4, 7.5 YR 7/8	Coarse-sandy clay	0.5	4.65
3a	7.5 YR 8/2	Coarse-sandy gravel	0.7	4.8
2	10 YR 7/8, 2.5 YR 6/8	Coarse-sandy gravel	0.0	4.7
1	10 YR 8/0, 8/6, 2.5 YR 6/6	Silty clay	0.0	4.5

Table 3

Sedimentology of Strata at the Budiño West Quarry (Textural classes after WENTWORTH system)

Bed	Munsell Color (Dry)	Textural Class	Per cent Ca CO_3	pH(H_2O)
North Face (Fig. 5)				
9	10 YR 3/2	Clayey coarse sand	0.1	4.55
8	10 YR 6/4	Clayey coarse sand	0.3	5.3
7 (top)	10 YR 7/4	Coarse-sandy gravel	0.0	5.6
7 (base)	10 YR 8/1	Clayey coarse sand	0.1	5.25
6	10 YR 8/0	Clayey coarse sand	0.0	4.55
5	10 YR 8/0	Silty clay	0.0	4.25
4	10 YR (white)	Clayey coarse sand	0.0	4.4
3	7.5 YR 8/0	Silty clay	0.1	4.55
2	10 YR 8/6, 5 YR 6/6, 2.5 YR 6/8	Clayey silt	0.0	4.7
1	10 YR 8/6, 10 R 4/6, 7.5 R 3/4	(Altered biotitic gneiss)	0.0	4.75
East Face				
(9)	10 YR 4/2	Silty coarse sand	0.1	5.1
(8)	10 YR 6/4	Clayey coarse sand	0.3	5.55
(7, top)	10 YR 8/3	Gravelly coarse sand	0.3	5.3
(7, base)	10 YR 8/2	Gravelly coarse sand	0.0	5.3

The Alluvial Terraces of the Lowermost Miño Valley

The earliest geomorphological study of the lower Miño valley, by H. LAUTENSACH (1941), identified Low, Middle and High Terraces, the first of which dip in relative level from + 10 m upstream to + 5 m downstream. This alluvium, which extends to at least 22 m below river bed, was described as an haugh loam (Auelehm) of Holocene age, aggraded during the Postglacial rise of sea-level. The two older terraces were similarly interpreted by eustatic control, in response to high interglacial sea-levels. The presence of deep, red weathering horizons on these upper surfaces was explained by warm interglacial climates. LAUTENSACH postulated severe tectonic deformation of the High Terrace, an error due to confusion of multiple terrace levels, as already pointed out by FEIO (1948).

A more recent, detailed study of the Portuguese side of the Miño (TEIXEIRA, 1952) showed the existence of 7 major terraces, limited to the lower course of the river. They maintain profiles graded to high sea-levels of 15—20 m ("Riss/Würm"), 30—40 m ("Mindel/Riss"), 50 m and 60—70 m ("Milazzian"), 75—70 m and 90—100 m ("Sicilian"). The lowest terrace, dropping from + 10/12 m upstream to + 5/6 m downstream, was ascribed to the Riss/Würm Interglacial by TEIXEIRA (1952). The Spanish side of the valley was studied by LÓPEZ et al. (1953) and broad terrace groups identified and mapped at + 12/20 m, + 30/40 m and + 45/70 m, the last divided into two substages. The floodplain terrace (TEIXEIRA's + 5/10 m level) was implicitly considered as a Holocene feature.

Thus, although there has already been considerable study of the Miño terraces, unclarities remain in the published work. Consequently a new survey of terrace levels, sediments and paleosols was carried out along the Spanish side of the Miño estuary, *viz.* the lower 40 km of the river subject to tidal influences today. A thorough study would have required many months, so that our survey was necessarily selective, emphasizing stratigraphic relationships, both internal and with respect to the Louro valley and the Atlantic coast.

The sequence of alluvial terraces recognized (Table 4, also Fig. 8) includes a Floodplain Terrace (FT, equivalent to LAUTENSACH's Low Terrace), a Low Terrace (LT) at +22/24 m., two Middle Terraces (MT I, MT II) at +42/44 m and +34/36 m respectively, and three High Terraces (HT I, II, III) at +76/80 m, +65/68 m and +52/59 m. Older still are a number of strongly denuded erosional surfaces between 130 and 250 m elevation, visible as sets of accordant summits, but providing no stratigraphic clues. The Floodplain Terrace drops in relative level from +8.5 m at Porto to + 3.5 m near the mouth of the Miño, where it is truncated at the edge of the tidal marshes. It is still inundated by late winter flood surges every few years (P. DIAZ ALVAREZ, pers. comm.), and according to TEIXEIRA (1952) annual high-water level ranges from + 6.5 to + 11 m. The top 4 m or so consist of stratified homogeneous, light brownish gray (2.5 Y 6/2), silty medium sand, rich in biotite, muscovite and detrital organic matter. The immature gray floodplain soil (a Paternia in the sense of KUBIENA, 1953: 158) is recorded by a weak mulliform A-horizon. Lower beds are coarser in texture, with bands of coarse to cobble-grade quartzite gravel, including rolled artifacts of most of the types recorded in the local Paleolithic (J. M. ALVAREZ-BLASQUEZ, pers. comm.).

All in all the concensus of evidence indicates that the Floodplain Terrace is post-Pleistocene in age. An identical deposit occurs in the Miñor valley (Fig. 1), falling downstream from + 4 m at Gondomar to + 2 m in the estuarine zone. It, too, is distinct from and truncated at the edge of the tidal-lagoonal deposits. Thus although the Floodplain

Fig. 8. North slope of the Miño Valley at Porto de Salvatierra, showing Floodplain (FT), Middle (MT) and High (HT) Terraces.

Table 4

Alluvial Terraces of the Lowermost Miño Valley (North Bank).
(Relative levels in meters with respect to mean low-water of the Rio Miño).

	Rosal	Goyán	Tomiño	Túy	Guillarey	Caldelas	Porto	Lower Louro	Middle Louro	General Level
Floodplain Terrace		3.5		6	6	6	8.5		10	3—10 m
Low Terrace	18	24.5	24	22	22	24.5			20	22—24 m
Middle Terrace II		34		36			29		29	34—36 m
Middle Terrace I	44	41	40/45			43		42		42—44 m
High Terrace III							59	52	52	52—59 m
High Terrace II						68	65	66	63	65—68 m
High Terrace I							76/80			76—80 m

Terrace is still periodically activated today, it is not an estuarine aggradation but, instead, takes the form of an alluvial fan, widening and thinning out in the lower river valleys. Silts and clays are largely carried out to sea, leaving behind the quartz and mica sands derived from older soils and slope sediments. Quite probably the exposed body of the Floodplain Terrace was mainly aggraded in response to accelerated soil erosion in the wake of deforestation during historical times.

The Low Terrace (+ 22/24 m) is preserved in small segments at many localities and is distinguished from the Floodplain Terrace by its composition: a sandy, coarse to cobble-grade gravel, consisting of about 75% quartzite, 15% sandstone and 10% pegmatitic quartz. In contrast to the Middle and High Terraces there are no indications of a red paleosol; instead a Meridional Braunerde forms the climax soil. The Middle Terrace complex (+ 34/36 m and + 42/44 m) consists of similar materials in comparable ratios, but there is widespread evidence of former rubefaction. No undisturbed profiles were found, except possibly at Volta Moura (see below), but truncated (B)C-horizons or inhomogeneous reddish yellow (5—7.5 YR 6/6) sediments, devoid of feldspars or micas, indicate the former presence of a reddish paleosol of moderate development. As in the case of the Low Terrace, this gravel unit forms a narrow border along the bedrock slopes that demarcate the margins of a once deeply-entrenched Miño gorge.

The High Terrace complex (+ 52/59 m, + 65/68 m, + 76/80 m) is distinct from the younger terraces. Extensive platforms underlie the gravels, forming conspicuous benches cut into the valley sides during extended periods of dynamic equilibrium. At several exposures HT III consists 100% of sandstone gravel, while HT II averages 25% sandstone, 60% quartz and 15% quartzite. In the case of HT I the sandstone component drops to 10%, quartz to 15%, while quartzite accounts for 75% of the gravel. Extensive spreads of Rotlehm sediments occur on all three surfaces, and truncated (B)-horizons are common. The typical constituent is a light red (2.5 YR 6/6—8), clayey silt or coarse-sandy clay, with coarse angular blocky structure. pH values lie near 5.0 and carbonates are absent.

All of the Pleistocene terrace gravels of the lower Miño are rounded or well-rounded by the modified LÜTTIG method (see BUTZER, 1964c: 160—164). In all but the oldest subunit (HT I), pebbles mechanically fractured during or after transport average between 0 and 6%, indicating no significant congelifraction. This value is unusually high (16%) in the case of HT I, possibly as a result of later soil frost. But even here syn- or epigenetic periglacial phenomena are entirely absent, either in the form of involutions or of laterally intercalated screes or solifluidal mantles. Sedimentologically, then, there is no contradiction in relating these terraces to non-glacial periods. Coarse to cobble-grade quartzite gravels are still carried in abundance in the bed of the Miño today, a fact readily explained by the steep gradient of the river upstream of Nieves and by a cultural landscape favoring rapid runoff. Also pertinent is the fact that the Pleistocene terraces each have gradients parallel to those of the modern river at low-water, but decidedly more gentle than that of the Floodplain Terrace. All this favors a base-level over a climatic stimulus to aggradation. There is as yet no evidence to suggest that the terraces are polygenetic, e. g., grading upwards from basal, cold-climate gravels to finer, interglacial deposits. Although glacial-age terraces are preserved in Orense Province and further upstream (VIDAL-BOX, 1941), any such alluvia in the Miño estuary would be found well below modern stream bed.

The relationships between the Miño and middle Louro sequences can be seen from Table 4, where the Louro levels are converted to relative elevations above low-water at Túy (3.5—4 m above sea-level). The Floodplain Terrace can be followed subcontinuously form Túy into the Louro valley, where it merges with the Louro floodplain. The Low Terraces of the two valleys, although not juxtaposed, appear to be equivalent on the basis of the paleosol stratigraphy, and the same can be said of MT II and HT II.

An interesting interdigitation of Louro and Miño facies can be observed in the case of HT III at Volta Moura, near Km 22.4—22.7 of the Vigo-Túy highway. The main body of HT III was injected over 6 km into the lower Louro as an alluvial fan from the Miño, dipping northwards (i. e., upstream) at 5—15° in a series of topset and foreset beds. These coarse exotic sandstone gravels are overlain by 2 m of medium-grade quartz gravels of Louro origin, bedded 1° downstream. Higher up in the sequence are another 3 m of Miño sandstones and sands. The entire exposure is covered by 20—120 cm of local colluvium, probably somewhat younger in age. A 1.5 m (B)-horizon, of lesser intensity than the Rotlehm relict soils of the High Terrace, is well-preserved on this colluvium, often penetrating down into the gravel. These exposures at Volta Moura help show the equivalence of the terrace sequences of the lower Miño and the middle Louro.

The immediate inference of these interrelationships is that the Lower Colluvium is younger than the Low Terrace of the Miño. Colluvial silts occur along the margins of many gravel terraces of the Miño valley, on both margins of the river (see also BERTHOIS, 1949). At the foot of bedrock slopes such silts tend to be sandy and mixed with kaolin, but below gravel outcrops they are rich in derived loamy soil products. A pollen study has been made from a deep loamy bed, rich in organic matter, resting on High Terrace gravels at 67 m near Corgos (ANDRADE, 1945). Almost certainly this light gray loam is a later colluvial deposit. Next to 23% non-arboreal pollen there were 57% *Pinus silvestris*, 9% *Quercus*, 5% *Salix*, 4% *Castanea* and 2% *Betula*. Presumably the one claim registered for Paleolithic artifacts *in situ* in the High Terrace near Lanhelas (VIANA, 1930) can be explained by a late Pleistocene colluvium resting on older beds. Significantly, Paleolithic artifacts have not been discovered within the Low, Middle and High Terraces of the Spanish side of the river. (J. M. ALVAREZ BLASQUEZ and P. DIAZ ALVAREZ, pers. comm.), and almost all of the surface sites are localized on top of the Low Terrace (see BOUZA-BREY & ALVAREZ-BLASQUEZ, 1952: Fig. 3).

Pleistocene Shorelines and Terrestrial Deposits between the Miño Estuary and the Ria de Vigo

The Atlantic coast between the mouth of the Miño and the entrance to the Ria de Vigo displays a great number of marine abrasional features, generally at elevations of no more than 50 m. North of Bayona such benches and platforms are found at irregular intervals in a rolling, well-articulated coastal landscape. Further south, an almost continous complex of platform remnants follows the base of the cliffs to the Sta. Tecla promontory and beyond, along the Portuguese littoral. By comparison, fossil littoral deposits are few and molluscan assemblages next to absent. On a coast with a spring tidal amplitude of 3 m or more, and exposed to frequent westerly and northwesterly gales, littoral sculpture is fairly effective and it is not surprising that older deposits have been destroyed. By contrast a thick mantle of late Pleistocene alluvial or colluvial beds is preserved almost continuously from Bayona to La Guardia.

At the mouth of the Miño there is a buried bedrock channel between Caminha Island and the Portuguese shore (Teixeira, 1950; Hydrographic Office, 1963: 78), although a bedrock bench at less than 3 m depth connects the island to the north shore. A unique fossil cobble beach has been described from the island itself by Zbyszweski & Teixeira (1949; Teixeira, 1952), who identify a *faune banale,* with three species of *Littorina,* two of *Patella* and one *Trochus,* all suggesting close proximity to the watermark.

The coastline beween Sta. Tecla and Vigo is by no means unstudied. Nonn (1958) has carried out detailed work on the ancient shoreline features of the Ria de Vigo, and further south Teixeira (1950, 1952), Parga *et al.* (1954), López *et al.* (1956), Nonn (1958), Fernández (1958), and Mensching (1961) have repeatedly confirmed the existence of littoral benches at various levels. But no systematic observations appear to have been carried out south of Pta. de Samil, or at least no sections have been published. Table 5 lists the marine platforms, benches, nips or notches recognized along this coastal sector during an intensive survey in 1963. There is little ground to question the validity of these values as accurate shoreline elevations related to features than can often be traced subcontinuously along much of the littoral with no apparent deformation (Fig. 9).

Table 5

Marine Abrasional Benches and Nips between the Miño Estuary and Vigo
(Elevations in meters above m. s. l. [mean sea-level]).

Pta. Samil	Outeiro	Pta. Elena	Sobreira/Oya	Sayanes/Chans	Playa Patos	Monteferro	Ramallosa	Bayona/Estelas	Mougas N.	Mougas S.	Villadesuso	Oya	Sanjián	Portocelo	La Guardia	Sta. Tecla	General Levels
1/2			?		2.5	?		?									2.5
					6/7				?	7				6		5	6/7
12		10?	10			10/12	10/12	10								11	10/12
			17											16		17.5	16/17
23		24	23/25		24			23							?	?	23/24
	35					33/35		32/36	34.5	33				35/36	36		33/36
45/50			45/50			44/46	48			41/51					45/50	45/48	44/49
						60											
				100/110													

The problem is whether these nips and benches refer to regional sea-level stages and, if so, whether such stages can be related to any specific, worldwide interglacial transgressions.

The geomorphic evidence suggests strongly that the 44—49 m stage, commonly developed in the form of a broad bench or platform, occasionally with a veneer of marine cobbles, represents a distinctive stratigraphic marker in the study area. North of Monte Sta. Tecla this platform extends inland, skirting the Rosal valley to merge with the 44 m Miño platforms and gravels (MT I) near Rosal. LAUTENSACH (1941) and TEIXEIRA (1952) have already attributed this striking platform-pass, interrupted by a former island-hill, to a Pleistocene arm of the Rio Miño. We strongly endorse this point of view. In fact this pass east of La Guardia is the one direct stratigraphic link between marine and fluvial phenomena at identical levels in the Miño estuary.

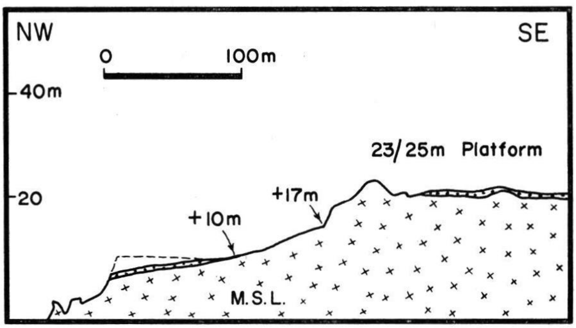

Fig. 9. Marine benches and nips at Punta Sobreira.

Marine stages above 50 m are not apparent in the coastal morphology, and although higher shoreline phenomena may once have been present, there is now no existing marine counterpart for the base-levels suggested by the High Terraces of the Miño.

The marine nips and benches at levels below 45—50 m represent more incidental abrasional features, obviously cut during briefer intervals of time. Nonetheless they afford evidence for at least 4 regional shoreline stages at 33—36 m, 23—24 m, 10—12 m, and 6—7 m. Lacking contemporary deposits, other than at Caminha (ZBYSZEWSKI & TEIXEIRA, 1949) and near Pta. de Samil (NONN, 1958), and without direct associations to the Miño terraces, these relative marine levels have no great stratigraphic value. They are all older than late Pleistocene continental deposits, as well as some basal marine gravels just above modern high tide. Also, correlations of the 33/36 m and 23/24 m shorelines with the MT II and LT of the Miño valley can be suggested, but not rigidly proven. Presumably all these shorelines relate to non-glacial intervals of the middle and late Pleistocene, but here again specific external correlations cannot even be suggested with any confidence. Thus although the marine-abrasional phenomena complement the Miño valley sequence, they provide no additional stratigraphic dating.

The late Pleistocene deposits of this same littoral are rather more rewarding and they provide some pertinent parallels to the colluvial sediments at Budiño. At Playa de Patos (Fig. 10, also earlier descriptions by NONN, 1958), ancient beach cobbles attain 2.3 m above mean sea-level (m. s. l.) and are overlain by up to 4.5 m of brown sandy silt and subangular coarse gravel of colluvial origin. A similar level also appears to be recorded by beach or estuarine sands near the high tidal mark just north of Pta. Sobreira.

North of Mougás there is a micro-karstic (Karrenkarst) surface at Km 67.3 (Fig. 11), developed in granite gneiss, and extending to above modern high-tide mark. This wave-worn surface marks a bench of interglacial age and is overlain by up to 3 m of semi-

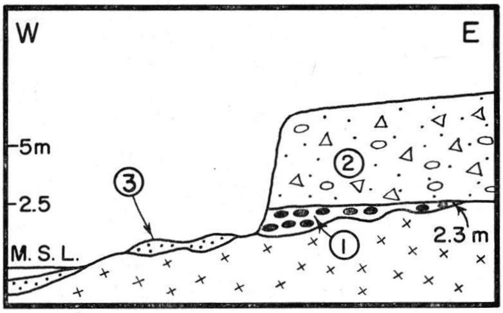

Fig. 10. Littoral and fluvial deposits at Playa de Patos. 1 = Last Interglacial (?) beach gravel; 2 = Late Pleistocene colluvium; 3 = modern beach sand.

consolidated, dark gray (10 YR 4/1) peaty sediment dipping 5° seawards. The organic component ranges from colloidal humus to fine, semi-carbonized plant matter with fragments of carbonized wood. A radiocarbon determination on such wood, 80 cm above base of sediment, gave "greater than 39,900 years" (I-2177). Quartz and muscovite sands are abundant throughout, and lenses of quartz grit gain in importance towards the top. The conformably overlying unit consists of 1.5—2 m of brown (10 YR 4—5/3), silty coarse sand, rich in humus, with the superimposed 40 cm dark gray A-horizon of a Ranker soil. Marine cobbles to + 8 m, resting on this soil profile, have been incorrectly

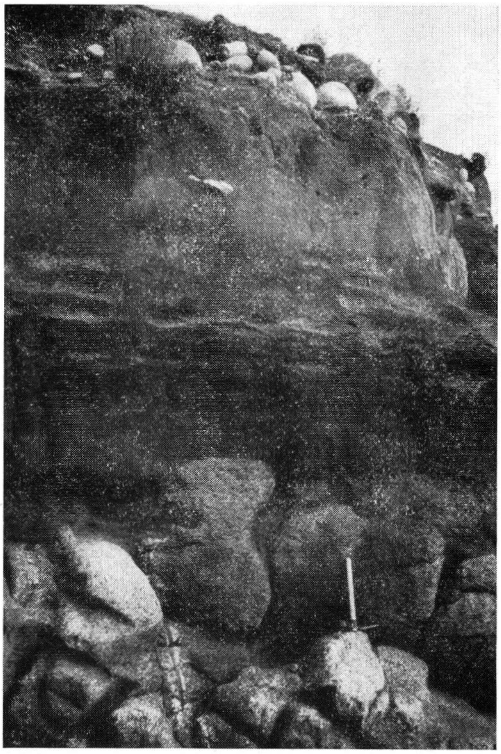

Fig. 11. Early Würm beds overlying wave-worn granite gneiss with Karrenkarst phenomena at Mougás (North) near Km 67.3. Sample I-2177 ("greater than 39,900 years") from black stratum of detrital organic matter, giving way at top to mineral deposits. Beach cobbles at top form part of artificial embankment and rest on A-horizon of recent soil.

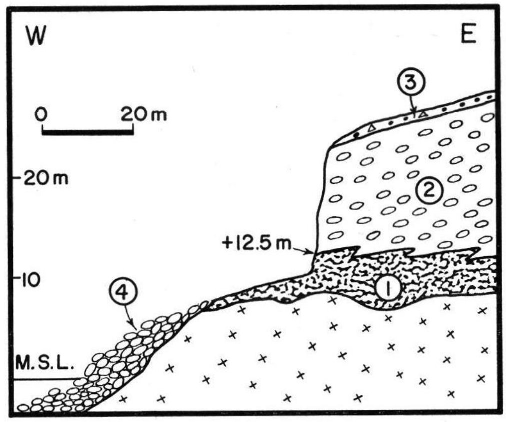

Fig. 12. Littoral and fluvial deposits at Sanjián, near Km 77.6. 1 = Detrital peat with date 28,400 B. P. (I-2261); 2 = Late Würm cobble gravels of Rio Cobo fan; 3 = humic, gritty colluvium; 4 = modern beach cobbles.

described as an interglacial beach (Zbyszewski & Teixeira, 1949, Pl. A, Fig. 2). They are part of the road embankment. All in all, the Mougás North section illustrates a sequence of early Würm colluvial deposits laid down over an emergent (last interglacial?) littoral bench.

An analogous sequence, of younger age, is exposed at Sanjián (Fig. 12), where up to 5 m of dark grayish brown (10 YR 4/2) organic silt underlie 15 m of well-rounded cobbles, with a matrix of dark yellowish brown (10 YR 4/4), silty coarse sand, and dipping 10° seawards. The cobble gravels represent a coarse alluvial fan of the ephemeral Rio Cobo, once extending to well below modern sea-level. The fan is overlain by 80 cm of very dark gray, highly humic, gritty colluvium, deposited prior to dissection with formation of two sporadic erosional benches visible along the Rio Cobo. A radiocarbon date of $28{,}400 \begin{smallmatrix} +1200 \\ -1000 \end{smallmatrix}$ years (I-2261) was obtained from carefully pretreated debris of carbonized wood and plant tissue from the basal organic stratum. In other words, the Sanjián beds pertain to the middle Würm, and presumably record the geomorphic transition from a cool-moist interstadial to the cold maximum of the Würm. The cobble gravels of Sanjián are probably identical to those seen in low-order stream valleys near Cabo Silleiro, at Villadesuso, Oya and between Portocelo and Fedorento.

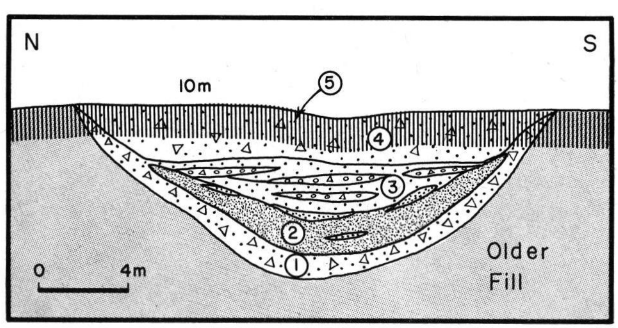

Fig. 13. Mid-to Late Würm beds at Playa de Fedorento, Area Grande, just north of La Guardia. Sample I-2176 (18,700 B. P.) from Older Fill. Younger Fill (units 1-4) and Holocene soil (5) described in text.

The stratigraphic picture is augmented further by sections from Area Grande, Playa de Fedorento, north of La Guardia (Fig. 13). At least two generations of late Pleistocene fill were carried out onto the emerged shelf by the small arroyo at this point. The Older Fill, apparently intercalated with cobble gravels a little to the north, consists of perhaps 10 m of unconsolidated pale brown (10 YR 6/3), silty coarse sand, with lenses of grit or gravel, and bands of diffuse moder humus or carbonized organic matter. A sample of organic detritus at 4 m below surface gave an age of 18,700 ± 320 years (I-2176). Following a period of dissection, another 4 m of Younger Fill were deposited in a rather narrow channel (Fig. 13):

(1) 50 cm. Organic silt with grit or medium grade detritus.
(2) 100 cm. Highly organic, dark gray (10 YR 4/1) sandy silt with grit lenses.
(3) 100 cm. Alternating bands of gritty brown (10 YR 5/3) sand and organic fill.
(4) 150 cm. Pale brown (10 YR 6/3) gritty sands, under
(5) 50 cm. Dark gray (10 YR 4/1) A-horizon of modern Ranker.

These type sites suffice to illustrate the nature of late Pleistocene continental deposits in the littoral zone. There are at least three generations of alluvial or colluvial deposits, the oldest of which rest directly on an interglacial beach platform. Broadly apeaking these units date from the early, middle and late Würm respectively. The middle unit correlates with the Lower Colluvium at Budiño and the youngest may be equivalent to the Upper Colluvium.

Stratigraphic and Paleoclimatic Interpretation

An overall evaluation of the Pleistocene geomorphology of southwestern Pontevedra may now be attempted in the light of the regional evidence. Firstly, the High Terrace gravels of the lower Miño and the Louro valleys pose a problem. Although they are graded to base-levels of 80 m, 65/68 m and 52/59 m, there is no evidence of corresponding shorelines on the Atlantic coast. Consequently an interglacial interpretation of these coarse deposits, although plausible, cannot be fully demonstrated. The limited evidence of congelifraction, in all but HT I, and the total absence of other soil frost phenomena, further militate against a cold-climate impetus to alluviation. Nonetheless there is a certain discrepancy between the stream competence indicated by the cobble gravels of the High Terraces and that to be expected today — at least if we exclude the effects of accelerated runoff in response to deforestation and cultivation. The possible role of periodic uplift of the Galician massif must therefore be born in mind.

The Rotlehm paleosols developed on the High Terrace complex record one or more periods of deep chemical weathering, presumably a warm climate with abundant moisture but an accentuated dry season (see Kubiena, 1954). On Mallorca and in Catalonia soils of similar intensity last developed during the late Tyrrhenian I (Butzer & Cuerda, 1962; Butzer, 1964b), in Soria during the interglacial succeeding the Elster II cold phase (Butzer, 1965). Broadly speaking, then, the High Terraces can probably be assigned to the early Pleistocene.

The Middle Terraces are more fully understood. MT I, at + 42/44 m, is physically connected to and at least partly contemporary with the long-term sea-level at + 44/49 m. MT II, at + 34/36 m, appears to be associated with a fairly significant sea-level stage at + 33/36 m. In this case direct field connections are unavailable. Despite their coarse calibre the Middle Terrace gravels are confined to the lower stream valleys and must be classified as interglacial deposits aggraded in response to tangible base-levels. The reddish paleosols locally preserved on the Middle Terraces lack distinctive profiles, presumably due to subsequent denudation of moderately shallow soils. Parallels with modest Braunlehm paleosols developed on the Middle Terraces in Catalonia (see Butzer, 1964 b) may be suggested. Lacking local paleontological evidence the Atlantic sea-levels cannot be dated stratigraphically, and it can only be inferred that the Middle Terraces of the Miño Louro are broadly middle Pleistocene in age.

The Low Terrace at + 22/24 m seems to be related to the + 23/24 m base-level suggested by widespread shoreline features along the coast. Intensity of subsequent soil development has not substantially differed from that characteristic during Holocene times. The age of this terrace is conjectural. At Budiño dissection and some tectonic displacement postdate the Low Terrace but predate the Lower Colluvium. And if the Low Terrace indeed correlates with the + 23/24 m shoreline, time must be allowed for cutting of the nips and benches at + 10/12 m and + 6/7 m, all prior to the Early Würm. Conceivably therefore the Low Terrace predates the Last Interglacial sea-levels now dated 75,000—90,000 B.P. in the Mediterranean Basin and along the Atlantic coast of Morocco (Stearns & Thurber, 1965). However, there can be little question about the warm-climate character of the deposits as such, with no evidence of frost, and fine to coarse bed-load deposits derived in good part from underminig of older gravels.

Three or more phases of colluviation or alluviation can be identified and informally defined during the Würm. The first of these is typified by the conformable colluvial sequence overlying the littoral bench at Mougás North. Older than 40,000 B.P. it must be Early Würm and can be designated as the Mougás beds. The second unit can be designated after the type site of Sanjián, and includes a conformable sequence of basal organic detritus grading upward into alluvial fans or talus cones. The lowest levels may still be "Paudorf" or Farmdale in age, ca. 28,000 B.P., while the youngest date from the late Middle Würm, ca. 16,000 B.P. or a little thereafter. These Sanjián beds are recorded along much of the coast between Bayona and La Guardia, and include the Lower Colluvium at Budiño. The final unit is typified by the Younger Fill at Playa de Fedorento and may be called the La Guardia beds. It probably includes the Upper Colluvium at Budiño and similar spreads as at Sanjián. A Late Würm age is postulated, partly in view of the similarity of facies with other Würmian deposits, partly in view of the date obtained from the basal part of a similar sequence in northern Galicia: 13,600 ± 450 B.P. (Sa-233, Delibrias *et al.*, 1964).

Each of the Würm units summarized above consists of an initial sediment rich in organic detritus, followed by mineral strata. This increase of grit or gravel components is symptomatic of a deteriorating soil and rooting network, in response to a more open vegetation or to a shift in precipitation regime. Whichever may apply, accelerated slope runoff, sheetwash and creep were responsible for deposition of eroded soil products and regolith in the footslope zone, as well as alluvial fans or cones at breaks of gradient in low-order stream profiles. Microscopic examination of the detrital organic matter and its moderate acidity (pH 5.0—5.7) suggest derivation from tangel humus (see Kubiena, 1953: 201—03) once mantling the slopes and uplands. Such soils are now found under alpine meadows of the Spanish sierras. Curiously, the zones of organic detritus are confined to deposits of the littoral and are more or less absent in the Louro valley. Mesoclimatic contrasts affecting the vegetation mat may have been responsible.

The Würm colluvia and alluvia of the study area can hardly be described as periglacial, even though their origin is best interpreted by a more severe, glacial-age climate with accelerated geomorphic processes. The hillslope and lowland sediments compare in facies and localization with the Würm-age colluvial silts and screes found below 500 m in Catalonia (Butzer, 1964 b) and in the Mallorcan sierras at elevations up to 1000 m (Butzer, 1964 a). Yet on the northern coast of Galicia, H. Nonn (1960, Delibrias *et al.*, 1964; Asensio-Amor & Nonn, 1964) describes congelifractate colluvia and alluvial or talus cones near sea-level, apparently with at least local evidence of cryoturbation and even of ice wedges. Similarly two pollen samples (from Burela and Cangas) yielded 77% and 81% non-arboreal pollen respectively. The tree pollen was almost exclusively *Pinus* cf. *silvestris*, today found above 1200 elevation in Cantabria. Without pollen studies from Pontevedran samples of similar age, the true magnitude of regional climatic differentiation between the northeastern and southwestern extremities of Galicia remains uncertain. But the deposits themselves show clearly that the morphogenetic environments were quite distinct.

Assuming a 10—12° F (6—7° C) drop of mean temperatures for the colder parts of the Würm, southwestern Pontevedra would still have enjoyed January mean temperatures above 32° F (0° C) and July means above 55° F (13° C). Within this perspective periglacial conditions would seem unreasonable for the study area, and a treeless environment is equally unlikely. Probably ericaceous heaths were widespread in response to a raw, wet climate, prone to frequent autumn and early spring gales and severe winter snowstorms. Rapid melting after each snowfall or accelerated runoff following heavy, persistent rains could easily set off mass-movements and sheetwash activity on intermediate and steep slopes. Modern analogies may be available from the northwestern coasts of Scotland or the southwest Norwegian littoral. But even there, areal denudation and mass-transfer of material is less significant than it once was in the study area. It may be that the primary factor of late Pleistocene morphogenesis in Pontevedra was the rupture of physical equilibrium attendant upon the climatic change from interglacial to glacial, from interstadial to stadial maximum.

The Holocene geomorphic record of the study area provides little conclusive evidence concerning possible climatic oscillations. Some of the facies changes apparent in the sub-alluvial part of the Floodplain Terrace may well not have been a result of human interference. However only palynological studies can hope to elucidate the more recent past.

Implications of the Budiño Site

Interpretation of the paleo-ecology of the Budiño Site is impeded by the lack of artifactual materials other than stone, particularly by the absence of bone. In fact, late Pleistocene mammalian faunas have yet to be reported from Galicia. Similarly the lack of palynological work in Pontevedra still precludes a reliable picture of the regional vegetation. Bearing these reservations in mind, the implements, flaking waste, anvils and hammerstones of the Budiño assemblage are nevertheless important when seen in their geological context and disentangled into functional activity-areas. This complex occupation horizon is contemporary with the Middle Würm Sanjián beds and records Paleolithic workshops and possible kill sites, periodically reoccupied over several centuries. The local environment was rather more severe than at present, as indicated by widespread colluvial detritus and indirect evidence of Tangel-Ranker paleosols. But climate was decidedly not subarctic in character.

The stratigraphic implications of the Budiño Site for archeological purposes are significant. Most of the artifact types represented in the surface collections of the lower Miño valley and, for that matter, northern Portugal, are here found *in situ* within a single occupation complex. Specifically, the Budiño artifacts are quite similar to collections that have been called Camposanquian, Languedocian or Asturian. The Middle Würm stratigraphic age and the radiocarbon dates (26,700 and 18,000 B.P.) are much later than what would normally be postulated on morphological grounds for the materials which have been called Camposanquian (or Languedocian). And they are much earlier than should be expected from an Asturian assemblage if the "Asturian" were indeed immediately pre-Neolithic in age. This suggests the possibility that the terms Camposanquian and Asturian refer to a temporally and formally heterogeneous agglomeration of artifact collections, rather than to single, definable industrial complexes. If this is so, the terms Camposanquian and Asturian should probably be dropped from use. Renewed research on materials previously included under these rubrics is in any case urgent. And one fact is abundantly clear from this site report, namely that the morphology of stone tools is by itself inconclusive for assignment to a given chronological position.

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References

AGUIRRE, E. DE: Las Gándaras de Budiño, Porriño (Pontevedra). Excavaciones Arqueol. en España, **31**, 28 pp., Madrid 1964.

ALVAREZ-BLASQUEZ, J. M., and F. BOUZA-BREY: Industrias paleoliticas de la comarca de Túy. Cuadernos de Estudios Gallegos **13**, 201-250, Madrid 1949.

ANDRADE, M. MONTENEGRO DE: Alguns elementos para o estudo do terraço superior do Rio Minho. Bolet. Soc. Geol. Portugal, **4**, 221-222, Porto 1945.

ASENSIO-AMOR, I. and H. NONN: Materiales sedimentarios de terrazas fluviales. Estudios geogr., **25**, 319-366, Madrid 1964.

BERTHOIS, L.: Contribution à l'étude des limons de la région nord du Portugal. Comunic. Serv. Geol. Portugal, **29**, 121-176, Lisbõa 1949.

BOUZA-BREY, F. and J. M. ALVAREZ: Industrias paleoliticas do Baixo Miño. Trabalhos Antropol. Etnol., **14**, fasc. 1-2, 3-65, Porto 1952.

BREUIL, H. and G. ZBYSZEWSKI: Contribution à l'étude des industries paléolithiques du Portugal et de leurs rapports avec la géologie du Quaternaire. II. Comunic. Serv. Geol. Portugal, **26**, 662 pp., Lisbõa 1945.

BUTZER, K. W.: Pleistocene cold-climate phenomena of the Island of Mallorca. Z. Geomorph., **8**, 7-31, Berlin 1964 (a). - - Pleistocene geomorphology and stratigraphy of the Costa Brava region (Catalonia). Abh. Akad. Wiss. Liter., Math.-Naturw. Kl., Nr. 1, 51 pp., Mainz 1964 (b). - - Environment and Archeology: an introduction to Pleistocene geography. 524 pp., Chicago and London, 1964. - - Acheulian occupation sites at Torralba and Ambrona, Spain: their geology. Science, **150**, No. 3704, 1718-1722, Washington 1965.

BUTZER, K. W. and J. CUERDA: Coastal stratigraphy of southern Mallorca. J. Geol., **70**, 398-416, Chicago 1962.

DÉLIBRIAS, G., H. NONN and M. VAN CAMPO: Age et flore d'un dépôt périglaciaire reposant sur la rasa cantabrique près de Burela (Galicie). C. R. Acad. Sci., **259**, 4092-4094, Paris 1964.

FEIO, M.: Notas geomorfológicas II. Em torno da interpretação dos terracos do Rio Minho. Bolet. Soc. Geol. Portugal, **7**, 44-54, Porto 1948.

FERNÁNDEZ DEL RIEGO, F.: Geognosia y geotectónica de la Ria de Vigo. Bol. Inst. Español de Oceanografia, **88**, 19 pp., Madrid 1958.

HYDROGRAPHIC OFFICE: Sailing directions for the west coasts of Spain, Portugal and Northwest Africa. U.S. Naval Oceanographic office, Publ. **51**, 407 pp., Washington 1963 (rev.).

KUBIENA, W. L.: Bestimmungsbuch und Systematik der Böden Europas. 317 pp., Stuttgart 1953. - - Über Reliktböden in Spanien. Aichinger Festschrift Bd. 1, Mitt. Inst. angew. Vegetationskde., 213-224, Wien 1954.

LAUTENSACH, H.: Interglaziale Terrassenbildung in Nord-Portugal und ihre Beziehungen zu den allgemeinen Problemen des Eiszeitalters. Petermann's Mitt., **87**, 297-311, Gotha 1941. - - Die iberische Halbinsel. 700 pp., München 1964.

LÓPEZ DE AZCONA, J. M., G. MARTIN CARDOSO, I. PARGA PONDAL, E. TORRE ENCISO and G. PIÑERO CORONEL: Túy (Pontevedra). Explicación Hoja 261, Mapa Geol. España 1 : 50,000. Inst. Geol. y Minero España, 94 pp., Madrid 1953.

LÓPEZ DE AZCONA, J. M., I. PARGA PONDAL and E. TORRE ENCISO: La Guardia (Pontevedra). Explicación Hoja 298, Mapa Geol. España 1 : 50,000. Inst. Geol. y Minero España, 37 pp., Madrid 1956.

LUCAS, J., H. NONN and H. PAQUET: Présence de niveaux à sépiolite et attapulgite dans des sédiments tertiaires de Galice. Bull. Serv. Carte Geol. Alsace-Lorraine, **16**, 227-232, Strasbourg 1963.

MENSCHING, H.: Die Rias der galicisch-asturischen Küste Spaniens. Erdkd., **15**, 210-224, Bonn 1961.

NONN, H.: Contribution à l'étude des plages anciennes de Galice (Espagne). Rév. Géograph. Pyrenées et SW, **29**, 257-267, Toulouse 1958. - - Les dépôts de la rasa cantabrique dans sa partie Occidentale. Rev. Géomorph. dyn., **11**, 97-105, Paris 1960.

NONN, H. and J. MÉDUS: Primeros resultados geomorfológicos y palynológicos referentes a la cuenca de Puentes de García Rodríguez (Galicia). Notas y Comm., Inst. Geol. y Minero España, **71**, 87-94, Madrid 1963.

NONN, H. and J. TRICART: Étude d'une formation periglaciaire ancienne en Galicie. Bull. Soc. Géol. France, (7), **2**, 41-44, Paris 1960.

PARGA PONDAL, I., E. TORRE ENCISO and J. M. LÓPEZ DE AZCONA: Oya (Pontevedra). Explicación Hoja 260, Mapa Geol. España 1 : 50,000. Inst. Geol. y Minero España, 28 pp., Madrid 1954.

PANNEKOEK, A. J.: The geomorphology of the Surroundings of the Ria de Arosa (Galicia, NW Spain). Leidse Geol. Med., **37**, 7-32, Leiden 1966.

STEARNS, C. E. and D. L. THURBER: Th^{230}-U^{234} dates of late Pleistocene marine fossils from the Mediterranean and Moroccan littorals. Quaternaria, **7**, 29-42, Rome 1965.

TEIXEIRA, C.: Plages anciennes et terrasses fluviatiles du littoral du Nord-Ouest de la Péninsule Ibérique. Bolet. Museu e Laboratório Mineral. Geol. Univ. Lisbõa, Nr. **7**, 1949, 33-48, Lisbõa, 1950. - - Os terraços da parte portuguesa do Rio Minho. - Comunic. Serv. Geol. Portugal, **33**, 221-245, Lisbõa 1952.

VIANA, A.: Estações paleolíticas do Alto-Minho. Portucale, **3**, 189-235, Porto 1930.

VIDAL-BOX, E.: Contribución al conocimiento morfológico de las cuencas de los Rios Sil y Miño. Bol. Real Soc. Españ. Hist. Nat., **39**, 121-153, Madrid 1941.

ZBYSZEWSKI, G., and C. TEIXEIRA: Le niveau quaternaire marin de 5-8 mètres au Portugal. Bolet. Soc. Geol. Portugal, **8**, 8 pp., Porto 1949.

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