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Source: *Journal of Coastal Research*, Vol. 8, No. 3 (Summer, 1992), pp. 593-602
Published by: Coastal Education & Research Foundation, Inc.
Stable URL: http://www.jstor.org/stable/4298008
Accessed: 28/06/2014 14:50

Journal of Coastal Research	8	3	593–602	Fort Lauderdale, Florida	Summer 1992

Morphology, Texture and Mineralogical Composition of Sandy Beaches in the South of Chile

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ABSTRACT

PINO, M. and JARAMILLO, E., 1992. Morphology, texture and mineralogical composition of sandy beaches in the south of Chile. *Journal of Coastal Research*, 8(3), 593–602. Fort Lauderdale (Florida), ISSN 0749-0208.

The coast facing the East Pacific near 40°S Latitude is characterized by a wide variety of sandy beaches. Different elevations were sampled along 16 beaches near Valdivia (Chile), to characterize variability in morphological, textural and mineralogical characteristics. Principal Component Analysis carried out with the mean values of 14 variables, showed that the first three components accounted for 73.4% of the total variance (Component I = 38.8%, Component II = 21.7%, Component III = 12.9%) and resulted in ordination of beaches in two main groups: one included fully reflective sites, which differed from the others by their coarser particles and steeper profiles (variables which loaded highest on Component I); the other group was comprised of beaches with dissipative and intermediate characteristics, as well as by sites with mixed characteristics. In the last group it was also possible to distinguish a sub-group of beaches, a distinction primarily based upon percentage of very fine sediments and shoreline orientation (two of the variables which loaded highest on Component II). The beach ordination results, and the interrelationships among the variables are discussed in relation to sediment provenance and hydrodynamic factors which form the beaches.

ADDITIONAL INDEX WORDS: *Pacific, south of Chile, sandy beaches, morphology, texture, composition.*

INTRODUCTION

The east Pacific coast of South America, located *ca.* 40°S Latitude (the coast of Valdivia, Chile; Figure 1) is characterized by rocky shores composed of metamorphic basement (ILLIES, 1960; OYARZÚN, 1986) as well as marine terraces of Pleistocene age whose main component is volcanic sand (BRÜGGEN, 1945; FUENZALIDA *et al.*, 1965; PINO and MULSOW, 1983; PINO, 1987). This area is included in an active margin zone in which the earthquake of 1960 produced vertical displacements of the shoreline in the range of + 5.7 m to − 2.3 m (PLAFKER and SAVAGE, 1970; PLAFKER, 1972). Along the coast near Valdivia, the subsidence reached about 2 m, resulting in the landward migration of sandy beaches. Lithologic and tectonic variability results in an alternation of crenulated ungraded and graded shorelines, with sandy beaches covering the full range from dissipative to reflective types. As demonstrated by SHORT and WRIGHT (1983), each type of beach occurs in a particular wave system. In addition, dissipative and reflective beaches may indicate different morphological and textural characteristics; (*i.e.*, generally, reflective beaches have steeper profiles and coarser grains than dissipative beaches).

The significant spatial variability of sandy beaches observed along the coast of Valdivia is one of the most distinctive features of this section of the Chilean coast. However, physical studies on those beaches are limited, a situation unfortunately typical of the entire Chilean coast. There are few studies of physical features of these beaches; ARAYA-VERGARA (1986) examined beach profile classifications and PORTER (1986) analyzed the mineralogy of some beaches located north and south of Valdivia.

The beaches of the coast of Valdivia are composed of terrigenous and allochemical components (FOLK, 1980). The former component is primarily represented by volcanic sand, which originated from marine terraces of Pleistocene age (PINO, 1988). Quartz, from schists of the metamorphic basement, is also present. The gravelly, coarse sediments of some areas are primarily rep-

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91014 received 19 February 1991; accepted in revision 14 February 1992.

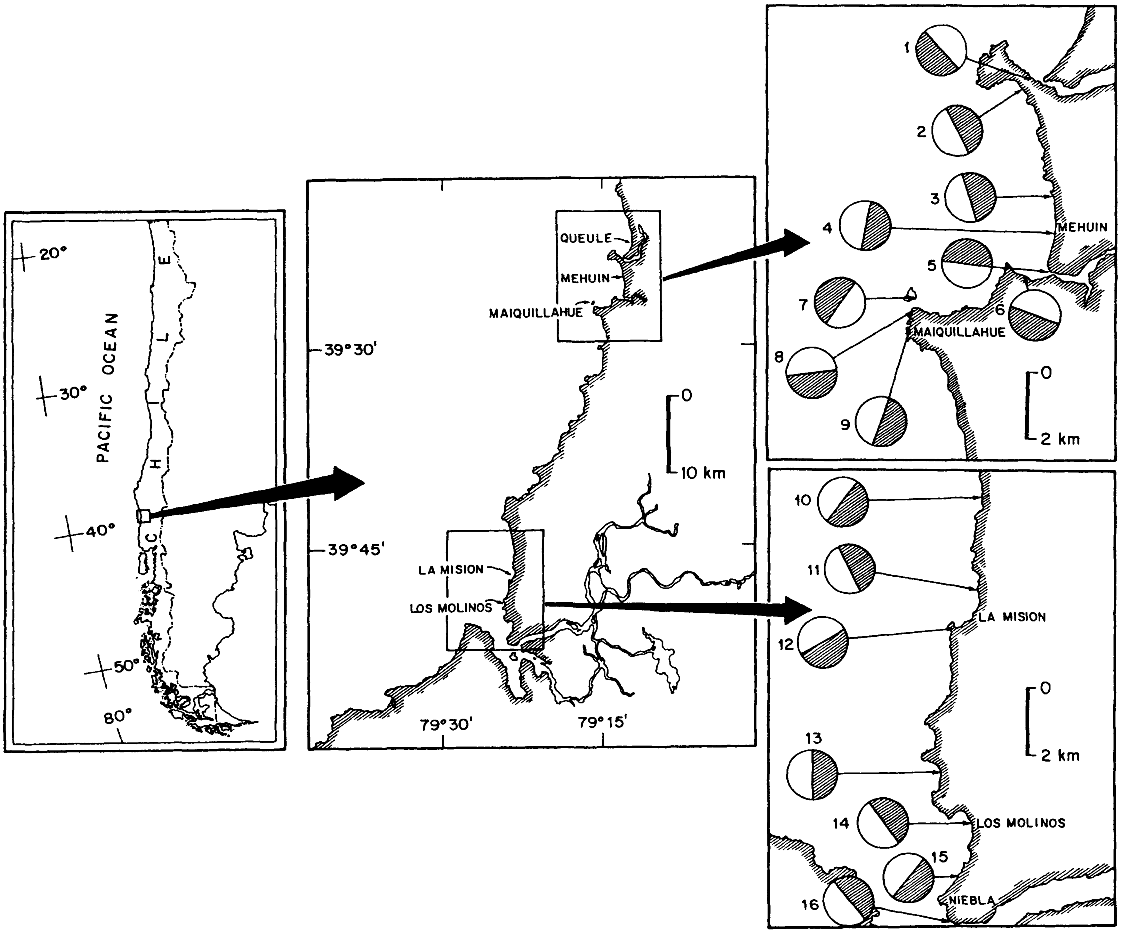

Figure 1. Map of the Chilean littoral showing the location of the studied beaches near the coast of Valdivia. Sites were concentrated at the areas of Queule-Maiquillahue and La Misión-Los Molinos. Shoreline orientation is represented as striped areas in each of the 16 circles (*i.e.*, beaches).

resented by fragments of igneous rocks originating in the Andean Range, and reworked from the coastal flood plains deposited during the last glacial period (MEDINA and PINO, 1989). The allochemical components (primarily shell gravel) are represented in the coarse sand to granule size range. These beaches follow seasonal accretion-erosion cycles, with periods of maximum sand accretion during late spring-early autumn (JARAMILLO, 1987), in which swell is more frequent.

The diversity in beach types along the coast of Valdivia (MCLACHLAN *et al.*, 1992), suggests a between-site variability in morphology, textural characteristics and related parameters. Thus, this study aimed to answer two main questions: (a) is there any relationship between beach morphology and sediment characteristics?, and (b) can patterns of textural characteristics to be related to patterns of provenance? To answer these questions we studied several beaches located in areas sufficiently separated so as to cover the widest possible range of morphological, textural and mineralogical characteristics.

MATERIAL AND METHODS

During the spring low tides of the summer–autumn of 1988 we visited 16 beaches near Valdivia (Figure 1). These beaches were typified using Dean's parameter (SHORT and WRIGHT, 1983) which is calculated as D = Hb/Ws × T, where Hb is breaker height in cm, Ws the sediment fall velocity in cm s^{-1} (GIBBS *et al.*, 1971) and T the wave period in seconds. On each sampling date we registered the wave height and period using the horizon and a stopwatch. That data set was compared with unpublished data on wave height and periods for the coast of Valdivia. We also used visual observations of morphological features (width of breaker zone, number of bars, presence and location of rip currents) in beach typification. At the location of each beach profile, the shoreline orientation was measured as departure from north (degrees); afterward, degrees were normalized through a logarithmic transformation. Topographic profiles from the backshore (*i.e.*, dunes or cliffs) to the low tide level of each beach with EMERY'S (1961) profiling technique. Differences in height across the profiles were measured at 5, 10 or 15 m intervals, depending on the width of each beach. The slope of the surveyed profiles was measured by the expression: $a/L \times 100$, where a is the difference in height between the highest and lowest points (low tide level), and L is the distance between these two points. The slope of each station was measured with a clinometer.

Two replicate samples of the upper few mm of sediment were collected at each of the stations studied along the surveyed profile of each beach. Stations were 5, 10 or 15 m apart, the same distances as that used to measure the elevations across the profiles. Sediment samples were desalted (tap water washing) and wet sieved through a -1 phi screen to separate gravel from the sand fractions. Thereafter, the sand fractions were analyzed for textural characteristics through a settling tube (EMERY, 1938; GIBBS *et al.*, 1971). Moment measures of mean grain size, sorting, skewness, and normalized kurtosis (kurtosis/kurtosis + 1) were calculated (SEWARD-THOMPSON and HAILS, 1973). At each station we also studied the percentage by weight of the 3.0–4.5 phi fraction obtained by sieving (very fine sands and coarse silts; WENTWORTH, 1922), the mean roundness of 100 quartz grains of the 2.0–3.0 phi fraction (FOLK, 1980), and the sediment porosity. The maximum porosity of the sand fraction represents the mean of ten measurements of the water volume needed to saturate a constant volume of uncompacted sediment. We also measured the percentages of silicates, magnetite and calcareous material in the sand fraction. These were obtained through successive elimination of magnetite and calcareous material with a magnet and HCl, respectively (INGRAM, 1971).

The eventual grouping of beaches according to their physical characteristics was obtained through Principal Component Analysis (Statistical Package Stratigraphic 2.0). Thus, the mean values for each of 14 variables were included in the analyses.

RESULTS

Table 1 shows that the beaches of Ronca, Universitaria and Grande de Mehuín had the highest values of Dean's parameter (> 6). These sites had the characteristics of dissipative beaches (*i.e.*, a well developed surf zone, flat profiles and fine sands). On the other hand, not all of the beaches which had the lowest values of Dean's parameter (< 1.5) fulfilled the characteristics of reflective beaches. Thus, while the beaches of Isla Maiquillahue, Caleta Maiquillahue, Maiquillahue Sur and Grande de Niebla had the features that characterize reflective beaches (*i.e.*, absence of surf zone, steep profiles and coarse grains), the protected beaches of Agua de las Niñas, Barra Lingue, Mississippi and Embarcadero de Niebla, all located at estuarine outlet areas, had mixed characteristics (*i.e.*, low values of Dean's parameter, absence of surf zone, variable profiles and fine sands) (Table 2). Finally, five beaches (Curiñanco, Calfuco, La Misión, San Ignacio and Los Molinos) had intermediate values of Dean's parameter (3.2–4.9) and also morphological features which are characteristics of intermediate beaches (SHORT and WRIGHT, 1983) (*e.g.*, long-wave megacusps and well defined rip currents).

The shoreline orientation was highly variable (294°); six beaches faced the northwest (beaches no. 4, 8, 9, 10, 12 and 15), six faced the southwest (beaches no. 2, 3, 5, 11, 14 and 16), two faced the northeast (beaches no. 1 and 6), another the southeast (beach no. 7), and the last faced the west (beach no. 13) (Figure 1). Different swell profiles were observed along the studied beaches. Those profiles are associated with the single and double sequence categories (ARAYA-VERGARA, 1986). Most of them were slightly convex, while that of Curiñanco, Calfuco, La Misión and San Ignacio had landward oriented inner face slopes (Figure 2).

Gravel sized sediments were only found at the sites studied in the area of Maiquillahue (beaches no. 7, 8 and 9) and at Niebla (beach no. 15). Gravel percentages ranged 5–21% (Table 2). The highest percentages of calcareous material (primarily mollusc shells) occurred at the beaches of the Maiquillahue area. The percentage of very fine sedi-

Table 1. *Name, location, width of the surveyed profiles, number of stations (*i.e.*, tidal levels) sampled, orientation and Dean's parameter of the sites studied.*

Beaches	Latitude	Width (m)	No. of Stations	Orientation (°)	Dean's Parameter
1. Agua de las Niñas*	39°23′27″S	55	7	45	1.5
2. Ronca	39°23′27″	115	12	217	6.8
3. Universitaria	39°25′25″	45	10	203	6.7
4. Grande de Mehuín	39°26′05″	140	8	176	6.7
5. Barra Lingue*	39°26′29″	25	6	256	0.8
6. Mississippi*	39°26′29″	60	7	67	1.5
7. Isla Maiquillahue	39°26′49″	25	6	319	0.8
8. Caleta Maiquillahue	39°27′10″	25	6	96	1.3
9. Maiquillahue Sur	39°27′22″	20	5	167	0.9
10. Curiñanco	39°45′00″	45	10	150	4.9
11. Calfuco	39°46′45″	110	10	195	4.2
12. La Misión	39°47′26″	30	7	134	4.4
13. San Ignacio	39°49′44″	70	8	180	3.2
14. Los Molinos	39°50′45″	40	5	206	4.1
15. Grande de Niebla	39°51′37″	40	5	145	0.9
16. Embarcadero de Niebla*	39°52′18″	60	8	229	1.4

* Beaches with mixed characteristics; *i.e.*, no surf zone, variable profiles and fine sands

ments (3.0–4.5 phi) was highest at the beaches of Playa Ronca (a dissipative type of beach where very fine sands accumulate at the backshore), Barra Lingue and Los Molinos, the later two displaying a high content of heavy minerals of small diameter (Table 2).

The granulometric parameters show that, apart from the sediments of the Maiquillahue area and Playa Grande de Niebla, well sorted medium and fine sands were the dominant type of sediments along the beaches studied (Table 2). As expected, the coarsest grained beaches had the lowest degree of sorting. Skewness values showed excess of fine and coarse grains. Both, sorting and skewness were significantly correlated with mean grain sizes; *i.e.*, the finest and best sorted sediments had the highest values of negative skewness (Table 2). Normalized kurtosis values show that most of the sands fall in the range of mesokurtic sediments (*ca.* 0.75). Table 2 also indicates that steeper profiles occurred at the coarse beaches of the Maiquillahue area and at the fine sands of Barra Lingue.

The porosity of the studied sands varied between nearly 39% and 45% (Table 2), usual ranges for this kind of sediments (BROWN and MCLACHLAN, 1990). Roundness values indicated that quartz particles fall in the subangular category (FOLK, 1980). Silicates dominated at all the beaches but Isla Maiquillahue which had the highest amount of calcareous material. Magnetite was an important component of only the beaches of Los Molinos, Grande de Niebla and Embarcadero de Niebla (beaches no. 14, 15 and 16) (Table 2).

In the Principal Component Analysis (Q mode) carried out with the mean values of the physical characteristics (14 variables) of the studied beaches (*i.e.*, N = 16 samples) (Table 2), the first three components accounted for 73.4% of the total variance (Component I: 38.8%, Component II: 21.7%, Component III: 12.9%). Mean grain size, slope (%) and % carbonates had the highest loadings in the first component; percentage of very fine sediments, porosity, roundness and beach orientation loaded highest in the second component, while % silicates, sorting and % of gravel were variables with the highest loadings in the third component (Figure 3).

The distribution of beaches in the space defined by the first three components is shown in Figure 4. The beaches of Playa Grande de Niebla and Maiquillahue (beaches no. 7, 8 and 9) are separated from the remaining beaches by Component I because of their coarse grains and steep profiles. Most of the other beaches were located on the upper and lower right quadrants of Figure 4. These beaches may be further divided; *e.g.*, beaches no. 2, 5 and 14, located in the upper right quadrant had higher percentages of very fine sediments (above 10%) than the other sites.

DISCUSSION

Mean grain size and wave characteristics are independent variables in the schemes currently

Table 2. *Mean values of the physical characteristics of the beaches studied. The means are based in the values obtained for each station.*

Beach No.	Orient.[1]	Slope[2] (°)	Slope[3]	Gravel (%)	v.f.s.[4] (%)	Mean (ϕ)	Sorting (ϕ)	Skewness	Kurt.[5]	Porosity %	Round.[6]	Silic.[7] (%)	Magnet.[8] (%)	Carb.[9] (%)
1	1.7	3.5	2.5	0.0	1.8	2.0	0.4	−0.3	0.7	44.7	2.2	94.8	2.6	2.7
2	2.3	3.7	2.0	0.0	13.0	2.2	0.3	−0.2	0.7	44.2	2.1	92.3	4.6	3.1
3	2.3	3.7	2.6	0.0	4.7	1.9	0.4	−0.5	0.7	44.2	2.1	94.1	3.6	2.3
4	2.3	3.0	2.6	0.0	5.2	2.0	0.3	−0.4	0.7	44.1	2.1	94.7	2.5	2.8
5	2.4	15.4	5.6	0.0	12.0	2.2	0.3	−0.4	0.8	44.5	2.1	90.0	6.9	3.1
6	1.8	3.4	2.6	0.0	0.6	2.0	0.4	0.7	0.8	39.7	2.4	93.8	3.9	2.3
7	2.5	9.6	6.1	6.7	1.2	0.5	0.4	0.8	0.8	43.8	2.1	42.1	1.9	56.0
8	2.0	10.8	6.1	21.0	0.9	1.1	0.6	0.0	0.7	43.0	2.1	86.2	1.9	12.0
9	2.2	14.3	8.1	5.8	0.4	0.6	0.6	0.9	0.8	42.8	2.1	87.9	2.1	10.0
10	2.2	4.6	2.1	0.0	0.3	1.6	0.4	0.0	0.7	38.9	2.5	92.8	4.9	2.3
11	2.3	2.7	1.8	0.0	2.7	1.8	0.3	−0.1	0.7	44.3	2.1	94.6	2.8	2.6
12	2.1	7.5	2.4	0.0	0.3	1.7	0.3	0.1	0.7	41.9	2.2	94.0	3.9	2.1
13	2.3	3.9	3.7	0.0	0.4	1.6	0.4	0.2	0.7	41.7	2.3	88.6	9.0	2.5
14	2.3	3.3	3.4	0.0	10.4	2.2	0.4	−0.2	0.7	45.2	2.1	82.0	16.1	1.9
15	2.2	6.3	5.3	5.1	1.5	1.1	0.6	0.3	0.8	41.2	2.1	86.1	12.1	1.8
16	2.4	2.9	3.2	0.0	3.6	1.8	0.5	−0.4	0.7	41.1	2.2	81.1	17.3	1.6

[1]log (° + 1) (see Table 1); [2](°) measured at each station; [3]a/100L (see text); [4]very fine sediments; [5]normalized kurtosis; [6]roundness (log of Power's scale); [7]silicates; [8]magnetite; [9]carbonates

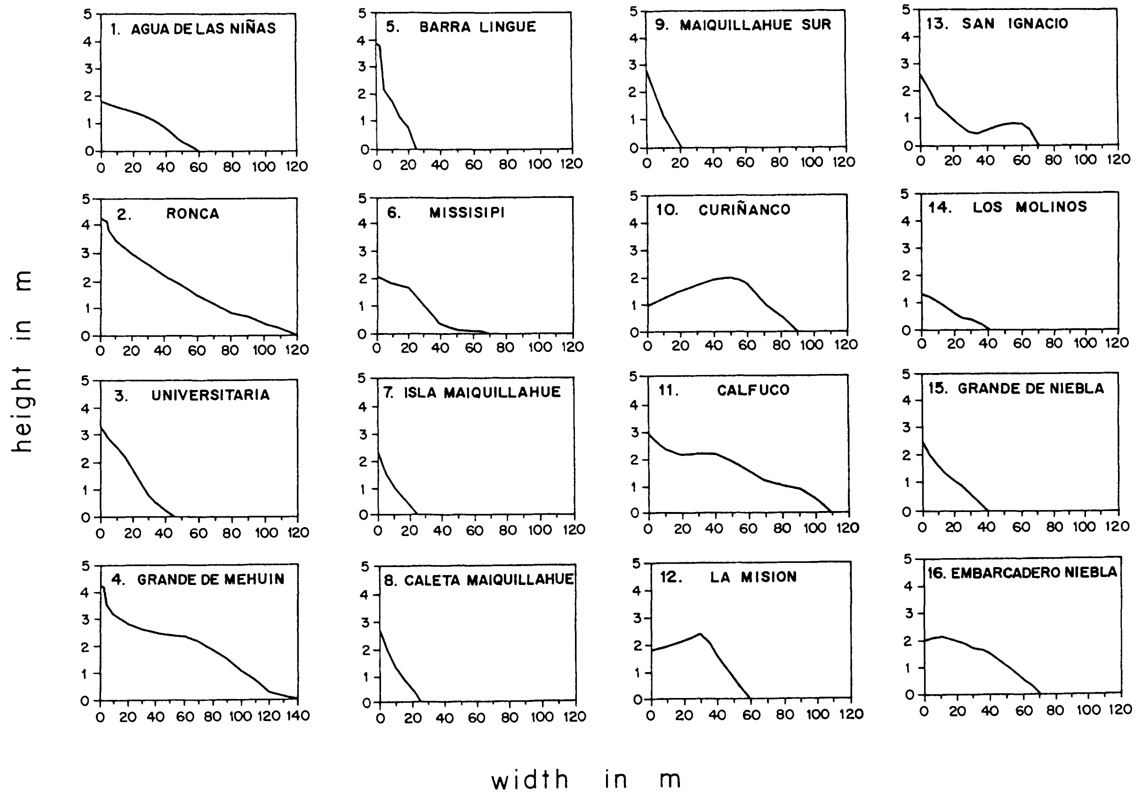

Figure 2. Beach profiles of the beaches studied near the coast of Valdivia. Horizontal scale is the same for all sites, but Grande de Mehuín.

used to categorize oceanic sandy beaches (*e.g.*, Short and Wright, 1983). Even though the first variable usually defines beach face slope (Bascom, 1951; Komar, 1976), it is quite difficult to separate the influence of provenance and hydrodynamic factors. For example, during sand accretion, the proportion of relict gravel in some of the studied beaches (*e.g.*, Grande de Mehuín, Los Molinos, Grande de Niebla) is quite low (< 1%; *unpublished data*). However, this proportion increases during storms (primarily in winter) when sand is eroded and gravel lag deposits result. In this case, the beach face slope increases as a result of increases in mean grain sizes produced by the hydrodynamic characteristics which occur during stormy periods. Therefore, all factors combine to produce the textural, bulk and mineralogical characteristics of oceanic sandy beaches.

The relationship between the coastal form of the studied area and the rock outcrops is distinctive. The graded coast of the southern sector is characterized by volcanic sandstone with abundant magnetite (Pino, 1987). This situation may give rise to the high percentages of magnetite at the beaches of Los Molinos, Grande de Niebla and Embarcadero Niebla (Table 2). Heavy mineral placers, occurring for example at Los Molinos, are accumulated when source rocks with high contents of these minerals are found in the cliffs bordering these beaches (Komar and Wang, 1984).

The gravel found at the beaches of the Maiquillahue area and Grande de Niebla is interpreted as a relict sediment, originating from the coastal flood plains of the last glaciation period (Medina and Pino, 1989). This interpretation is similar to that used by Clemens and Komar (1988) to explain the distribution of heavy minerals in the Oregon coast; *i.e.*, gravelly sediments would have been deposited at the external zones of bays (*e.g.*, Maiquillahue area) during lowering sea levels. Periodic samplings carried out at the beaches of Los Molinos and Grande de Niebla showed that

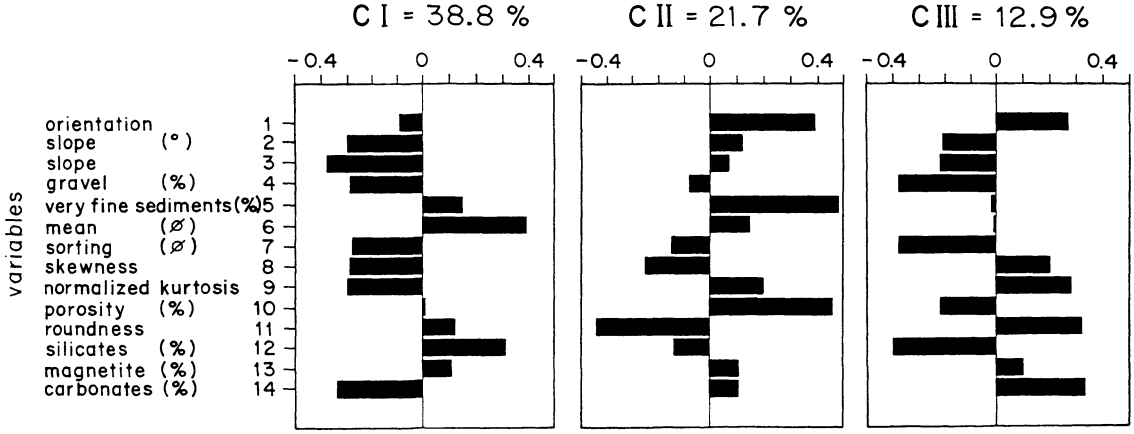

Figure 3. Loads of each variable in relation to the first, second and third component of the Principal Component Analysis.

gravel was always present in the sediments, with higher proportions during storm periods (*unpublished data*). Apart from the high content of gravelly sediments at the beaches of the Maiquillahue area, sites 7, 8 and 9 also had a high content of calcareous sand, a feature probably related to the local accumulation of abundant mollusc shells and sea urchin tests which occurs at this area.

The sites studied covered a wide range of beach categories; however, the spatial variability of mean grain size and sorting was quite narrow (*e.g.*, narrower ranges than those of *e.g.* beaches of Argentina (ISLA, 1987) and Australia (DAVIES, 1989). The spatial variability amongst textural parameters in the area studied was primarily related to the existence of relict gravel and calcareous material and also to the percentage of fine sediments. Skewness values were negative or positive, a situation probably related to differences in winnowing or deposition (coarse and fine-skewed, respectively), or to the sediment source (*i.e.*, existence of very coarse sand associated with gravel or carbonates and very fine sediments, respectively). Kurtosis values were quite homogeneous, distributions being quite close to the mesokurtic situation, with the exception of site 7 (Isla Maiquillahue, Figure 1) which tended to be bimodal (Table 2). The steep slope of this beach is the result of both the high content of gravel, and also the high percentage of calcareous sand (pieces of shells), the irregular shapes of which produce high repose angles and high percolation rates.

In general, our results agreed with the usual direct relationship between beach face slope and mean grain size (BASCOM, 1951; SHEPARD, 1963; MCLEAN and KIRK, 1969). The exception to this general trend was the beach Barra Lingue, a site with fine sands and a steep slope. The latter is probably related to the high content of heavy minerals in the fine sand fraction, as observed in a sandy beach of Lake Michigan (DUBOIS, 1972): the heavy minerals increase the sand weight, and therefore the resistance to particle erosion by backwash. If the backwash is less effective in eroding sands with a high content of magnetite and

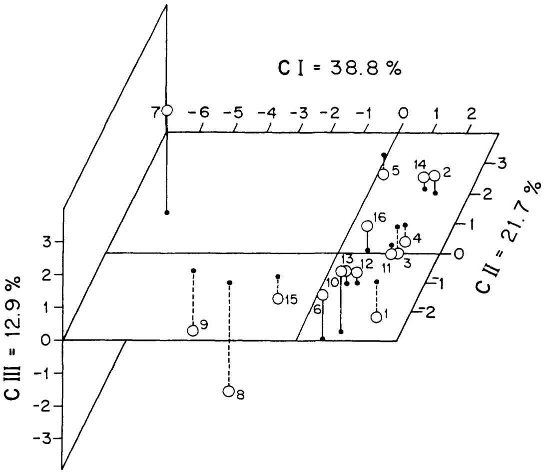

Figure 4. Ordination of the 16 beaches studied in the space originated by the first three components of the Principal Component Analysis (see text).

heavy minerals, the beach face slope increases in order to maintain an equilibrium between wave process and gravity (Dubois, 1972). The effect of backwash is also influenced by the rate of water percolation, which depends on grain size and sorting. Thus, sorting of sediments also affects beach face slope as shown by McLean and Kirk (1969) for mixed sand-shingle beaches of New Zealand. In this study, sediments with sorting values higher than 0.5 phi had high beach face slopes. These relatively low sorting values were not produced by bimodality, as in the study of McLean and Kirk (1969), but were a consequence of the presence of coarse, positive skewed sediments (sites 8, 9, and 15, Table 2).

The results of the multivariate analysis indicated that mean grain size, beach face slope and percentage of carbonates were the primary variables separating different types of beaches. Thus, the fully reflective sites (*i.e.,* those with the coarsest grains and steepest slopes; beaches no. 7, 8, 9 and 15, Figure 4) were clearly separated from those with dissipative, intermediate and mixed characteristics. Whereas dissipative and intermediate sites had similar wave regimes (*i.e.,* both types had a surf zone), those with mixed characteristics were similar to the reflective sites because both lacked surf zones. However, beaches with mixed characteristics (*i.e.,* those located at estuarine areas) differed from the reflective sites because of their fine grains.

Shoreline orientation and percentage of very fine sediments were important variables for distinguishing beaches with dissipative, intermediate and mixed characteristics. Thus, the beaches of Ronca, Barra Lingue and Los Molinos (beaches no. 2, 5 and 14, respectively), the sites with the highest percentages of very fine sediments (mean = 11.8%) were separated from the other sites in the Principal Component Analysis (Figure 4). Along the Chilean coast, high waves are usually associated with north and north-west winds, the main source of winter storms during which waves may be up to 5 m high. While such high waves occurs during 4% of the winter season, waves ranging from 0.8–2.2 m (swell regime) are observed during more than 40% of the year (Araya-Vergara, 1981). It is probable that swell deposits the very fine sediments on the beaches facing west to southwest.

In conclusion, this study has shown that along a short segment of the coast near Valdivia (*ca.* 80 km in a straight line) morphodynamic oceanic beach stages coexist. These are similar to beaches which have been described for other latitudes. However, different beaches of mixed characteristic are located at estuary outlets. Fully reflective beaches were separated from all the other beaches by sand mean grain size and beach profiles. Most of the other beaches were not fully separated among themselves; indeed, a gradual dispersion of samples (sites) was detected in the graphical representation of beaches with dissipative, intermediate and mixed characteristics. Beaches with different morphodynamic characteristics were not separated in the Principal Component Analysis: the separation of the reflective beaches was primarily due to the presence of relict gravel. This fact, apart from that of the local provenance of sand, suggests that provenance is more important than hydrodynamics in the separation of reflective beaches.

ACKNOWLEDGEMENTS

We are grateful to the graduate students and technical assistants working with us at the Marine Biology Laboratory of Mehuín, who helped with the field and laboratory work. We thank Anton MacLachlan (University of Port Elizabeth, South Africa) and an anonymous reviewer for valuable comments of an earlier draft of the manuscript. This study was supported by CONICYT (Project FONDECYT 0904-88).

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☐ RESUMEN ☐

El sector costero del Pacífico Suroriental en los alrededores de los 40°S se caracteriza por la existencia de una amplia variedad de tipos de playas arenosas. Se muestrearon diferentes niveles en 16 playas del litoral de Valdivia (Chile), con el objetivo de caracterizar la variabilidad de las características morfológicas, texturales y mineralógicas. Un Análisis de Componentes Principales basado en el promedio de 14 variables, mostró que los tres primeros componentes explicaron el 73,4% de la varianza total (Componente I = 38.8%, Componente II = 21.7%, Componente III = 12.9%). Tales resultados mostraron la configuración de dos grupos de playas; uno, constituído por playas de tipo reflectivo y basicamente diferenciadas del resto por sus partículas mas gruesas y perfiles mas inclinados (variables de mayor peso en el Componente I), y otro formado por playas disipativas y de características intermedias y mixtas. Dentro de este último grupo, también fué posible discernir un subgrupo de playas, separamiento basado en el porcentaje de sedimentos muy finos y orientación de la linea de costa (dos de las variables de mayor peso en el Componente II). Tal agrupamiento de playas y las interrelaciones entre las variables, se discuten en relación al origen de los sedimentos y factores hidrodinámicos que forman de las playas.

☐ RÉSUMÉ ☐

On a trouvé sur la côte Est Pacifique, vers la latitude de 40° Sud, une grande variètè de plages sableuses. On a échantillonné différents niveaux le long de 16 plages à proximité de Valdiva (Chili), afin de caractériser la variabilité de la morphologie, de la texture et de la minéralogie. Une analyse en composante principale sur les valeurs moyennes de 14 variables montrent que les trois premières composantes rendent compte de 73,4% de la variance totale (I = 38,8%, II = 21,7%, III = 12,9%) et ordonnent les plages en deux principaux groupes. L'un inclut tous les sites de plage à réflexion qui diffèrent de toutes les autes par leurs particules plus grossières et leurs profils plus pentus (variables qui ont le plus de poids sur la composante I). L'autre groupe comprend des plages de type à

dissipation et de type intermédiaire, comme des plages mixtes. Dans ce dernier groupe on a aussi pu distinguer un sous groupe, distinction d'abord basée sur le pourcentage de sédiments très fins et sur l'orientation du rivage (deux variables qui ont le plus de poids sur la composante II). Le classement des plages et les relations entre variables sont discutés en rapport avec la provenance des sédiments, les facteurs hydrodynamiques générant les plages.—*Catherine Bousquet-Bressolier, Géomorphologie E.P.H.E., Montrouge, France.*