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FOURTH INTERNATIONAL CONFERENCE ON GEOMORPHOLOGY - Italy 1997
Session: Littoral and Submarine Geomorphology

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SYNTHESIS OF THE PAPERS PRESENTED

Within the notable development of Geomorphology during the last decades, one of the sectors that has awakened greater interest, not only of researchers who investigated both scientific and applied aspects but also of bodies delegated for territory management, is Coastal Geomorphology. This great interest is proved by more than 100 participants who attended the session on «Littoral and Submarine Geomorphology» of the Fourth International Conference on Geomorphology, which took place at Bologna University on September 1st, 1997. The session started with a short introduction by its Chairman Dieter H. Kelletat from Essen University, Germany. He gave some technical information and in particular pointed to the fact, that coastal topics made nearly the largest number of all contributions on this conference, if all the coast related papers and posters within other sessions were included. All in all 95 contributions on coasts and oceans can be found in the Abstract Volume of the Conference, many of them by Italian collegues, who have a long tradition in coastal geomorphology, and a very high standard of related techniques and publications including beautiful coloured maps.

Compared with former decades, as represented in extensive bibliographies like those of the Coastal Commission of the International Geographical Union with more than 20,000 references during the last thirty years, we learn that the main interest in coastal geomorphology has been put on depositional coastal features including beaches and beach erosion and protection, foreshore sediment dynamics, foredunes, deltas, and tidal flat geomorphology. More than 35% of the papers and posters of this session dealt with these subjects. Another about 30% presented problems of dating in general, Pleistocene and Holocene sea-levels, or neotectonics, and only 10% with submarine features. Papers on rocky shores in general or on abrasive phenomena, on coastal biogeomorphology, or on distribution patterns were nearly missing totally. These subjects should be more developed in the future. A rather large amount of papers and posters have been dedicated to complex regional studies, and from them about 50% dealt with European examples, 30% alone with Italy. They fill the too many gaps in our knowledge on the world's coastline.

Nevertheless during the last 20 years a doubling and intensifying of coastal research and publications, in particular in Asia, Africa, and South America could be observed, and more periodicals on coastal sciences have been founded. The amount of national and international scientific bodies dealing with coasts have increased significantly, as well, documented by new working groups, sub-commissions or commissions on oceans and coasts within the International Quaternary Association (INQUA), the International Geographical Union (IGU), the International Geological Correlation Programs (IGCP), the International Geosphere - Biosphere Program (IGBP) with core projects like Land Ocean Interaction in the Coastal Zone (LOICZ), the European Union on Coastal Conservation (EUCC), the organisation Eurocoast, etc.. One result of this and the growing awareness, that oceans and coasts have been neglected in geosciences so far, is the proclamation of the United Nations International year of the Ocean 1998 with meetings in Genova and Lisbon.

If we look on the posters and papers presented for this session and compare their subjects with those of main interest in international organisations of coastal sciences mentioned, we find that the scope of papers in Bologna does not reflect their core projects in general. The reason for this may partly be that some of the chapters of coastal science like Pleistocene and Holocene chronologies, neotectonics, or absolute dating can be found in other sections of this conference. Of course many new ideas evolve daily from the scientific community of coastal researchers

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worldwide, but only a few of them survive to form backbones of longer lasting international programs. Therefore we would like to point here to those subjects in coastal geomorphology which need further development and more intensive studies. The list is by far not complete, but we hope that meetings like this and the chance for personal contacts among scientists from different schools of coastal geomorphology, working with different tools and techniques and in different regions of the world, will promote at least some of these subjects in the near future. So we feel the necessity to intensify coastal research , without giving a ranking herein,

– on mapping the distribution of all coastal phenomena (a matter of course, but unfortunately not very much developed);
– to promote GIS and coastal monitoring programs as well as integrated coastal zone management tools, in particular for questions of global change and environmental protection;
– to intensify research on coastal biogeomorphology, which by far is not treated adequately and is missing nearly totally in our textbooks and handbooks of coastal geomorphology, except of the coral reef and mangrove belts;
– to analyze the complexity of forming processes at rocky shores worldwide;
– to intensify interdisciplinary research with history and archaeology on one hand and with biology and ecology on the other hand;
– to develope dating techniques like Radiocarbon, ESR, TL, OSL, and others, to harmonize them for different kinds of material and latitudinal environments, solving problems of the so called reservoir effect as well as to establish more reliable chronologies for all latitudes and coastal situations.

The quantification of coastal processes as well as of neotectonics should be involved herein

– to check high magnitude-low frequency events to separate their geomorphological effects from the long-lasting slower processes of normal magnitude and frequency;
– to combine the results from coastal research (in particular its chronologies) with those from the terrestrial environments in the vicinity. In too many cases their stories are contradictory, and the idea to connect results from both sides is not very much developed.

The aim of more efforts in coastal geomorphology should be to bring to the scientific and public community – with more efforts and more effects than now – the importance of analysing coasts as the most extended, extremely quickly changing and vulnerable ecosystems of the world. This would help for a better understanding of natural and manmade influences on global change, and it would deliver better tools as well for establishing concepts for conservation of our environment or at least for a sustainable development of areas under severe ecological and economical pressure.

After this introduction two papers have been presented orally, the first on «Dimensional analysis of coastal foredune changes» by N.P. Psuty from Rutgers, New Jersey, USA (co-authors P.A. Gares, W. Svekla & A. Diener). This study is an inquiry into the alongshore variability of coastal dune response to high frequency events like storms, because these events have an immediate direct impact, establish antecedent conditions for subsequent storms, and usually are influenced by the local beach and nearshore morphology and by human modifications of the system. The dune changes for five sites within the state of New Jersey have been monitored between October, 1994 and September, 1996, and the volumetric changes could be related to storms of different magnitudes. The pre- and post-storm cross-sectional areas are compared to determine the foredune changes and the alongshore pattern of erosion and accretion. The study demonstrates that with single events, there are areas of dune accretion as well as erosion within short segments of the shoreline. These variations establish antecedent conditions for future modifications of the dune system.

The second oral presentation was given by R. Raffi from Roma/Italy, on «Recent Evolution of the Beaches of Calabria (Italy)» (co-authors L. D'Alessandro, L. Davoli & E. Lupia Palmieri). The paper discussed the longterm studies during the past century and in particular the past 40 years on the 700 km long Tyrrhenian and Ionian coastlines of Calabria and defined both natural and anthropic causes of variations, relied on analysis of historical records, as well as geomorphological, pluviometric and anemological enquiries. Surveys were carried out not only on the shorelines but on the tributary catchment basin as well, to identify the entity of solid supply to the sea. Shoreline variations were investigated on the basis of maps and aerial photographs, allowing the reconstruction of their history since 1850. The different evolution of the Tyrrhenian and Ionian beaches relate to their different configuration: Tyrrhenian beaches are thin strips at the foot of steep slopes and have small catchment areas with short streams. Conversely, wider beaches are found at the foot of the Ionian side with gentler slopes, larger catchment areas and longer streams, cutting through highly erodable lithologies. Along the Tyrrhenian side the abrasion platforms are narrower and the sea bottom is steeper than at the Ionian side. These differences infer that Tyrrhenian coasts are more vulnerable and thus undergo erosion. The erosional crisis has been triggered by a sharp increase in wind speed and frequency and a radical drop in calms from 1954 to 1978, but control measures in the drainage basins, quarrying from the stream beds and beaches have disrupted the equilibrium, as well. Ionian beaches underwent erosion more than 20 years after Tyrrhenian ones, and a decrease in precipitation may have played a significant role in the evolution of the beaches of Calabria, as well.

At the end of the «Oral Papers» session the participants gathered again for a final discussion, analysing thoroughly the topics dealt with in both papers presented.

The session continued with the presentation of the «Poster Session» by the Convenor Claudio Caputo from the University «La Sapienza» of Roma, Italy. Among the announced posters, at the Conference 29 have been presented enclosing nearly all topics of littoral and submarine

geomorphology. In order to better point out the main arguments, the poster session was divided into eight subsessions, each dedicated to a specific theme, namely: 1) Delta; 2) Tidal flats, beaches and beach dynamics; 3) Bars, nearshore environments and dynamics; 4) Coastal dunes and eolian dynamics; 5) Rocky coasts, cliffs and abrasion: 6) Pleistocene shorelines, sea level rise and Holocene sea levels; 7) Regional studies; 8) Submarine geomorphology. This subdivision has been evidently made taking into account the arguments which were more emphasized by Authors.

Authors of posters came from 15 countries belonging to Europe, Asia, Africa and both North and South America. All posters were of great interest both for the wide range of topics touched on, and for the geographical distribution of examples cited.

The *first theme,* («Delta»), has been object of three posters. The topic touched on by Pranzini was the evolution of a cuspate delta, considering not only the growth under negligible or increasing river sediment load, but also the conditions of sedimentation at the river mouth. Furthermore an illustration was given on longshore current directions and river course evolution during both growth and erosion of this kind of delta. These theoretical speculations were followed by a short description of the field validations found for two Italian cuspate deltas, i.e. those of the Arno and Ombrone rivers.

Still on cuspate deltas was the investigation by Gabbianelli & Elmi. These Authors described some aspects of the evolution of the Reno river mouth (Italy). Its modern mouth represented during historical times the place of two cuspate deltas of the Po river. The reconstruction of these delta bodies showed that their largest extension did not reach or pass the present coastline with exception of the late Roman and the Renaissance deltas which correspond to the present Reno river mouth. Methods of reconstruction vary from historical-archeological information, to inland geomorphological elements and high-resolution seismic survey pointing the existence of submerged evidences of the Roman delta.

Sedimentological, micropaleontological and palinological studies were carried out on some cores sampled on the prodelta and drilled in the delta plain of the Centa river (Liguria, Italy) by Arobba & *alii.* Authors outlined environmental changes at this wave dominated delta and, through these analyses as well as by two radiocarbon dates, they sketched out the Holocene delta system evolution. Moreover Authors outlined the changes this delta underwent, considering aerial photographs, historical written records and stratigraphic-seismic sections of the continental shelf.

To the *second theme* («Tidal Flats, Beaches and Beach Dynamics») three papers have been dedicated. Topics exposed chiefly concerned regional or local problems of coastal dynamics.

Houwink & Terwindt focussed in their poster the problem of reclamation work consequences for marshes along the mainland of the Dutch Wadden Sea. This area, after having suffered erosion for the last two centuries, experience now an accretional situation. This is mainly due to the presence of pioneer vegetation in the higher part of the intertidal flats, vegetation which may be important for increasing net sedimentation rate and thus extension of the marsh zone. Authors selected two test sites to investigate hydro-biodynamic interactions and made some considerations on the effects observed and on measures necessary for management possibilities.

Heyse presented the results of a year multidisciplinary program having as object morphodynamic evolution of the Middlekerke Sandbank environment (Flemish Banks), which was selected within European Projects. Specifically, short, medium and long term evolutions have been studied as well as detailed investigations aiming to map morphological features, to determine hydrological conditions and to evaluate sand budget evolution of the sandbank, considering also impact of extreme storm events upon bottom morphology.

A theoretical approach was the paper by Evangelista & *alii*, who discussed the littoral dynamics modeled from wave climate data across the bottom topography within the Circeo-Terracina coastal area (SE of Roma). Authors calculated the effects of wave refraction, diffraction and height modification, upon wave approaching the coast, using a program that considers spectra of heights, periods, and directions of waves. On the other hand the values of longshore transport, current velocity, shear stress, significant breaker height were calculated along profiles transverse to the shore.

Three posters were included in the *third theme* («Bars, Nearshore Environments and Dynamics»).

The paper by Mikhailova concerned a quantitative analysis of the results of field investigations of the river mouth morphology, morphometry and morphodynamics in non-tidal deltas of the Caspian Sea and Black Sea. As a reference and comparison the Author used also data coming from other important river mouth bars in deltas of different parts of the World (Russia-Siberia, Lituania, Poland, China and USA).

Mitina made a hypothesis on individuation of what she defines «bottom natural complexes (BNC)» and which extend over the whole submerged beach area where the change from oscillation to progressive waves occurs. The two main complexes singled out – the bay with abrasion terraces and the bay with accumulative terraces – are divided into simple complexes (f.e. modern abrasion terrace), sub-complexes (f.e. fore-delta), facies series and facies. This hypothesis seems to arise from studies carried out along the easternmost coast of the Sea of Japan.

De Muro & *alii* carried out geomorphological, sedimentological, and chronological studies on an area in NE Sardinia. Collected data allowed to compile a map at large scale containing information referring to the more dynamic zone of the submarine beaches. Surveyed deposits are ascribed by Authors to a recent coastal geomorphologic evolution affecting the littoral environment and proximal shelf during the late Holocene transgression.

Five papers concerned the *fourth theme* («Coastal Dunes and Eolian Dynamics»). Main topics touched on were techniques used in investigations and analyses on dune formation and mobility.

Heikkinen & Brusila described research techniques on dune sand movement employed in the field for researches carried out in Finland. Authors evidence which methods are suitable for different purposes, like dissemination and saltation of sands, wind direction definition, stratification of dunes, changes in morphology and vegetation of dune areas, as well as for dating accumulation and deflation events just in these areas.

Allen & Psuty identified rhythmic, alongshore patterns in shoreline and foredune mobility at different scale in space and time. Data and results coming from dataset for Fire Island (New York, USA) improve theoretical knowledge of alongshore barrier island morphology and can be used for coastal hazard assessment, resource management planning and engineering designs.

Sherman & Farrell, after having investigated on shear velocity-saltation layer interaction, demonstrated how field experiments suggest that the mean height of saltation is relatively insensitive to shear velocity changes, at least in transport conditions typical to beaches and, on the other hand, emphasize that basic physical relationships may be transferred with some difficulty from laboratory to field.

Claudino-Sales & *alii* described dunes and small lakes and ponds in the NE coast of Brazil. The analysis of dune distribution and typology allows to single out sand migration and remobilisation. Besides there are dune systems which, at some periods of the recent coastal evolution, must have been disconnected from their sediment source. Authors assume that possible interruption may be due to multiple reasons, like climatic changes, trade wind regime and shore drift variations, fluvial drainage/sedimentary coastal budget variations and man induced alteration of the coastal dynamic system.

Olivier & Garland critically reviewed the results of survey and analysis techniques used for foredune formation in part of the South Africa coast, discussing some difficulties encountered and providing suggestions for future surveys.

The only paper presented for the *fifth theme* («Rocky Coasts, Cliffs and Abrasion») was by Kostrzewsy & Zwolinsky and it described field studies dedicated to the functioning of the modern denudation system in Wolin Island (Poland). These investigations embrace different issues on cliffs as impact of lithology, plant cover, slope angle, quantitative and qualitative evaluation of effects of morphogenetic processes, rate of retreat etc. These systematic and multiyear studies on this cliff coast, which suffered also catastrophic processes, allowed to establish regularities of present morphodynamics and its trend within this morphogenetic environment.

The largest number of posters (10) was dedicated to the *sixth theme* («Pleistocene Shorelines, Sea level Rise and Holocene Sea Levels»), thus making understand that this topic on Quaternary sea-level changes is for most researchers a very interesting and stimulating matter of discussion to deal with. Seven of these posters deal with the Mediterranean area of influence, while the other concern South America.

Brandolini & *alii* discussed the refinement of results of a previous geomorphologic survey made at the coastal-fluvial plain of the Polcevera valley (Liguria, Italy). Authors singled out different orders of planation surfaces which allowed them to describe the paleoenvironmental evolution of the area, taking into account the effects of tectonics, geomorphological, sedimentological, and paleobotanical analyses on material obtained by soundings.

The morphological evolution of the coastal plain close to the Phlegrean Fields volcanic district (Napoli, Italy) has been described by De Pippo & *alii*. This evolution is strictly connected with the pyroclastic eruption occurred during the last 14,000 years. Volcano-tectonic events, interacted frequently with submersion and uplift of large coastal areas, at different times among which the Roman period, Middle Ages and the last two centuries testified by the position of villas, ports and other structures. In addition, during the last 2,000 years, the bradyseism, with its up-and-down movements, played an important role. Considering these historical and volcano-tectonic events, as well as stratigraphic reconstructions based on drillings and sedimentological analyses, and datings, Authors estimated in about 8 m the total subsidence degree of the plain during the past 3,700 years with an average rate of 2 mm/y.

Dini & *alii* considered the reconstruction of the Holocene evolution of the coastal area in southern Apulia (Italy) pointing out its tectonic trend in recent times. This area is characterized by a staircase of marine terraces and the effects of relative Holocene sea-level changes are recognizable both on rocky coasts and main beaches. Submarine surveys evidenced at −4 m the presence of either submerged platforms or openings of submerged sea caves. Authors carried out also radiocarbon age determinations on two eolian units (dune belts and fields). Data collected allowed to suggest a relative high sea level stand in mid-Holocene times, while the altimetric position of forms genetically linked to this sea level stand stress the different uplift rates having characterized the main structural blocks recognized in southern Apulia.

Geomorphic features and subbottom data, allowed Colantoni & *alii* to reconstruct the late Quaternary shorelines of the Central Adriatic coast (Italy), as well as to point out how their evolution has been controlled by tectonic movements. Authors single out the location of a Flandrian shoreline located 12 to 2 km inland as from the present shore, a drowned barrier coast (8,000 B.P.) at 30 km from the present one at 40 m depth, and the Roman shoreline (2,100-1,900 B.P.) at 6 km to 1 km inland. In the southern part (northern Marche) the two shorelines (Flandrian and Roman) are external to the present one along the coast cut into hard rocks, while when soft sediments are present the two lines are internal and marked by continuous scarps.

Fumanal & *alii* discussed about geomorphological changes that the Valencian littoral area (Spain) underwent during the Upper Quaternary. This evolution has been studied analysing sedimentary bodies (bio- and lithofacies) and determining the chronostratigraphical and paleogeographical sequence of that area. Conclusions that can be drawn are the evaluation of eustatic oscillations in western Mediterranean during recent Quaternary and their influences on the Valencian coast; climatic changes and asso-

ciated morphogenetic processes and finally the role of neotectonics were also discussed.

Roque & Palli described the submerged platforms discovered in different places of the Costa Brava (Spain) and which are interpreted as ancient beach deposits showing compositional and textural characteristics very similar to those of today. Age of beaches has been determined through archeological remains and absolute dating. The detailed study of one of these beaches allowed to single out three different superimposed levels, the upper of which seems to have deposited during a phase followed to a sea-level drop.

Romanescu tried to reconstruct the location of paleodeltas and paleorivers originated in the Danube delta area (Rumania) during the lower Pleistocene and Holocene. Analyses carried out confirm that the oldest distributary channel of the delta is the southernmost, while the middle channel is at the same time the more recent one. The evolution of this delta area has to be related with eustatic oscillations of both the Black Sea, and the Mediterranean Sea.

Angulo & Lessa discussed the Holocene mean sea level curves established for Brazil. The old curves, drawn about 30 years ago, show a same general contour with a fall of sea level after a maximum of about 5 m after the post-glacial transgression (about 5,000 B.P.) with intercalation of two intervals of negative oscillation (4,100-3,800 and 3,000-2,700 B.P.). Authors make a re-evaluation of the sea-level data use to determine the maximum elevation of the Holocene transgression and the two secondary oscillations. The elevation of paleo sea-level indicators derives from vermetid radiocarbon datings, and must have reached about +3.5 m at 5,100 B.P. to which followed a smoother decline. Data do not support secondary oscillations.

De Muro & *alii* presented a map, at a scale 1:50,000, on which they reported the results of a coastal geomorphological survey concerning marine and transitional terraces of Punta Catalina (Strait of Magellan, Chile). The map produced belongs to an atlas of about 12 geomorphological maps which is still being completed. Authors focussed their researches especially on the youngest terraces; these are mostly depositional flat bodies, but at times they are part of erosion surfaces. As from the present sea level Authors identify three order of terraces at heights ranging from 25 m to 3 m, all belonging mainly to Holocene.

Still dedicated to the coasts of the Strait of Magellan (Chile), and with the same aim of completing the above mentioned atlas, was the poster by Di Grande & *alii*. Authors described the evolution of the coastal area between the Atlantic Ocean and Paso Ancho and which has been a significant morphodinamic unit since Lower Holocene. Its recent evolution is mainly linked to the last glaciations and to their deposits. The western part shows a regular series of mainly marine terraced deposits arranged in three orders, the oldest being Lower Holocene in age, while the last averages about 4,000-5,000 years B.P.. Other terraced surface of fluvial and/or glaciofluvial origin are recognized by Authors at altitudes heigher than 25 metres.

For the *seventh theme* («Regional Studies») two papers have been presented. The first, by Meçai & Berxholi illustrated the physical environment and the geomorphological features of the central coastal part of Albania focussing the attention on the Durres-Vlora Region situated completely on lowland. The morphodynamics of this area is connected with two processes: i) an accumulation and deposition which changes the coastline replenishing beaches with sand mostly continental in origin, and ii) strong or moderate processes affecting the low laying shores and much less the cliff coast. According to Authors the evolution of the coastline of this region is directly linked to the fluvial dynamics where the solid sediment input causes the spreading of the river mouths, beach progradation, sand dune development etc.. Where this sedimentary input decreases the coast undergoes a general destruction. Sealing of some delta branches and opening of new ones may be, on the other hand, cause of coastal geometry change.

The second paper, by Ollerhead, described the studies conducted at Cape Jouriman (New Brunswick, Canada), where the Confederation Bridge to Prince Edward Island is attached. The studies aimed to document the shoreline geomorphology and the sedimentary characteristics of this site in order to monitor environmental parameters that may influence the bridge construction. Therefore shoreline profiles have been established and bottom and dune sampling have been collected, also to map the bottom composition of that area. Moreover investigations on recent and longer-termed evolution of the sandy barrier system have been undertaken using surveys, aerial photographs and historical maps and records.

Finally the *eighth theme* («Submarine Geomorphology») collected two posters both dealing with subjects connected with global tectonics.

Kagami discussed the problem concerning the continental shelf limit of the active margin, arising from the difficulty to provide the natural prolongation of the continent in case of the accreted oceanic ridge across trenches. After having analysed different examples of accreted oceanic ridges, the Author remarks that these ridges are included to the continental shelf regime. Moreover he takes into account the presence of possible seamount chains or long ridges and concludes by stating the current distance of the outer limit.

Griboulard & *alii* described the relations between active tectonics and submarine geomorphology analysing the tectonic accretionary prism of Small Antilles which they consider one of the most spectacular models of lithospheric convergence. The results of two oceanographic cruises allowed to single out relations among sub-surface structures, morphological elements and the surrounding structural frame. In particular the mapping of morphological elements made it possible to recognize the basic role of tectonics at whatever scale. All data have been confirmed in their essence also by submersions. The study carried out by Authors demonstrated also the importance of ablation-erosion as well as reworking phenomena for the sedimentary supply of basins.