Il Quaternario
Italian Journal of Quaternary Sciences
24, (Abstract AIQUA, Roma 02/2011), 8 - 10

Congresso AIQUA
Il Quaternario Italiano: conoscenze e prospettive
Roma 24 e 25 febbraio 2011

POST-LGM VALLEY FILLS FROM THE NORTHERN COAST OF TUSCANY: DEPOSITIONAL FACIES AND STRATIGRAPHIC ARCHITECTURE

Alessandro Amorosi[1], Veronica Rossi[1], Giovanni Sarti[2] & Roberto Mattei[2]
[1] Dipartimento di Scienze della Terra e Geologico-Ambientali, University of Bologna, Italy
[2] Dipartimento di Scienze della Terra, University of Pisa, Italy
Corresponding author: A. Amorosi <alessandro.amorosi@unibo.it>

ABSTRACT: Amorosi A. *et al., Post-LGM valley fills from the northern coast of Tuscany: depositional facies and stratigraphic architecture.* (IT ISSN 0349-3356, 2011)
The stratigraphic architecture of three adjacent valley bodies of post-LGM age buried beneath the northern coast of Tuscany is illustrated in detail. Above a gravel fluvial deposit, the valley fills exhibit a distinctive succession of coastal plain to estuarine facies, punctuated by an aggradational stacking pattern of millennial-scale depositional cycles with distinctive climatic signature. Radiocarbon dates document that the three valleys were active simultaneously and that rapidly created accommodation during transgression was filled under conditions of very high sediment supply.

RIASSUNTO: Amorosi A. *et al.,* Riempimenti vallivi tardoquaternari nel sottosuolo della piana costiera toscana: facies e architettura deposizionale. (IT ISSN 0349-3356, 2011)
Il sottosuolo della costa toscana tra Pisa e Viareggio è caratterizzato da tre paleovalli, formatesi nel corso dell'ultimo ciclo glaciale-interglaciale. Al di sopra di facies ghiaiose di canale fluviale, il riempimento delle paleovalli presenta un impilamento aggradazionale di parasequenze di piana costiera ed estuarine, formatesi in risposta a oscillazioni climatiche e del livello marino di durata circa millenaria. Datazioni al radiocarbonio mostrano che le tre paleovalli furono attive contemporaneamente e che il loro riempimento avvenne durante la risalita del livello del mare in condizioni di elevato apporto sedimentario.

Key words: Valley fill, Sequence Stratigraphy, Parasequence, Quaternary, Tuscany

Parole chiave: Riempimento di valle, Stratigrafia Sequenziale, Parasequenza, Quaternario, Toscana

1. INTRODUCTION

The three-dimensional stratigraphic architecture of late Quaternary valley fills has received increasing attention in the past decade, following the development of several sequence-stratigraphic models during the 1990s (VAN WAGONER *et al.* 1990; DALRYMPLE *et al.* 1994; ZAITLIN *et al.* 1994). However, given the difficulties in performing accurate geometric characterization of Quaternary valley bodies on-land, where studies are mostly conducted on the basis of core analysis (Gibling 2006), most examples of Quaternary incised-valley fills stem primarily from offshore seismic investigations.
After the early work by BELLOTTI *et al.* (1994), MILLI (1997) and MILLI *et al.* (2008) on the Tiber coastal plain, detailed facies documentation of late Quaternary valley-fill sequences from the northern Tyrrhenian coast has been recently provided by AGUZZI *et al.* (2007) and AMOROSI *et al.* (2008; 2009) for the Arno River system. This paper expands from previous work in the Tuscan area, extending stratigraphic analysis of the post-Last Glacial Maximum (post-LGM) succession to a 30 km-long transect, approximately parallel to the present Tyrrhenian Sea shoreline, from Pisa to Viareggio. This transect enables the comparison of the stratigraphic architecture beneath three adjacent river systems: Arno, Serchio and Stiava-Camaiore.

2. MATERIAL AND METHODS

A dataset consisting of 2,600 stratigraphic data, with 40 continuously-cored reference boreholes, was used for this study. A wealth of information exists for the Pisa area and the Arno River. Conversely, lower density stratigraphic data are available for Serchio and Camaiore-Stiava river systems. In addition to the Arno River (242 km long and with water discharge of about 110 m^3/sec), the study area includes Serchio River (length: 111 km, discharge: 46 m^3/sec) and Camaiore-Stiava river basins. Arno and Serchio rivers are the main fluvial courses of northern Tuscany, with catchment areas of 8228 km^2 and 1400 km^2, respectively. In contrast, Camaiore River is just 19 km long, while Stiava River is even shorter.
Facies characterization of the post-LGM succession also benefited from the analysis of the meiofauna (benthic foraminifers and ostracods) found within five reference cores (BERGAMIN *et al.,* 2006; AMOROSI *et al.,* 2009). A total of twenty-five radiocarbon dates previously published in BERGAMIN *et al.* (2006), MARIOTTI LIPPI (2007) and AMOROSI *et al.* (2009) allowed to tie facies interpretation from cored wells into a sequence-

stratigraphic framework.

3. POST-LGM FACIES ARCHITECTURE

Stratigraphic correlation of core data collected along a cross-section transversal to the present fluvial-channel axes enables the identification of a *suite* of genetically related valley bodies that fill the incisions formed by Arno, Serchio and Camaiore-Stiava rivers during the last glacial/interglacial cycle. Valley bodies are 5 to 10 km wide and 30 to 45 m thick, with width/thickness ratios of about 100 -300.

On the basis of facies analysis and palaeontologic characteristics, the valley fills can be subdivided into a series of millennial-scale depositional cycles (see AMOROSI *et al.* 2009). These cycles show that valley filling was associated with alternating freshwater and brackish conditions. Individual small-scale cycles, about 10 m thick, are bounded by flooding surfaces (parasequences *sensu* VAN WAGONER *et al.,* 1990) and display similar facies architecture, with sharp-based central/outer estuarine clays grading upwards into inner-estuary and coastal-plain deposits. Facies architecture within the valley bodies shows an aggradational, rather than retrogradational, stacking pattern of parasequences.

Diagnostic changes in vegetation patterns enable documentation of small-scale cycle development as a function of climate change (AMOROSI *et al.,* 2009). Particularly, pollen spectra show expansions of broad-leaved forests at parasequence boundaries, suggesting that rapid shifts to warmer climate conditions accompanied episodes of rapid sea-level rise. In contrast, stillstand phases saw the development of cold-temperate communities (upper parts of parasequences). The sedimentary response to these short-term phases of climatic cooling is documented by episodes of widespread coastal-plain and bay-head delta progradation, which led to partial estuary infilling and temporary establishment of continental environments in the proximal and central sectors of the valleys.

4. SEQUENCE STRATIGRAPHY

The post-LGM succession overlies alluvial deposits assigned to the last phase of base-level fall and subsequent lowstand. However, it can not be ruled out that part of the fluvial gravel bodies accumulated under early transgressive conditions. On the interfluves separating the major valley bodies the three deeply incised erosional surfaces (sequence boundary) pass into correlative subaerial exposure surfaces, characterized by indurated and weathered horizons associated with significant stratigraphic hiatuses. At these locations the sequence boundary merges with the transgressive erosional surface, marking the evolution of the incised-valley systems into wave-dominated estuaries. The lower transgressive systems tract (TST), which accumulated between ca. 13,000 and 7,800 cal yr BP, records the progressive infilling and drowning of the Tuscan paleovalleys in response to the rapid post-glacial sea-level rise. The three valley fills exhibit a composite succession of organic-rich muds formed in a coastal-plain or inner-estuarine environment, with upper transition to central- and outer-estuarine clays (lower TST). An aggradational stacking pattern of high-frequency depositional cycles within the valley fills suggests that sediment supply to the estuaries kept pace with increasing accommodation due to rapid sea-level rise in the early stages of transgression.

The upper TST, which marks the change from an aggradational to a retrogradational depositional style, is characterized by a marked deepening-upward tendency (transition to thin nearshore and shallow-marine deposits) and by a typical erosional lower boundary (wave ravinement surface). The maximum flooding surface separates the TST from the overlying highstand systems tract (HST). Its age is very well constrained in all valley fills around 7,800 years BP on the basis of radiocarbon dates. This almost isochronous surface, which represents the Holocene peak of transgression in the study area, has no obvious physical expression, but can be easily identified from core samples containing the most marine-influenced microfossil assemblage.

5. CONCLUSIONS

Few studies have dealt with synchronous valley incision and filling during the last glacial/interglacial cycle as deduced from borehole data. Close examination of a valuable stratigraphic dataset beneath the Tuscan coastal plain penetrating the post-LGM succession shows the presence of three coexisting incised-valley systems oriented roughly normal to the present shoreline. The application of sequence-stratigraphic analysis through the identification of significant stratigraphic surfaces enables the interpretation of depositional-facies origin and distribution of the post-LGM succession in the study area. Above lowstand/early transgressive fluvial deposits, the three valley fills share a common depositional style, including a transgressive succession of inner- to outer-estuary facies. Where high-resolution core descriptions are available, including micropaleontological and pollen characterization, depositional cycles of lower rank (parasequences) can be delineated within the valley bodies. The vertical succession of facies suggests that the three valleys experienced a common depositional history. Fluvial incision occurred close to or during the LGM, while wave-dominated estuaries developed into the valley systems during the ensuing post-LGM phase of sea-level rise. The three valley fills keep record of very high sedimentation rates (about 1 cm/year). Sediment supply kept pace with sea-level rise during the early stages of transgression, leading to a distinctive aggradational (and even weakly progradational) facies architecture within the valley bodies.

REFERENCES

AGUZZI M., AMOROSI A., COLALONGO M.L., RICCI LUCCHI M., ROSSI V., SARTI G. & VAIANI S.C. (2007) - *Late Quaternary climatic evolution of the Arno coastal plain (Western Tuscany, Italy) from subsurface data.* Sedimentary Geology, **211**, 211–229.

AMOROSI A., SARTI G., ROSSI V. & FONTANA V. (2008) - *Anatomy and sequence stratigraphy of the late Quaternary Arno valley fill (Tuscany, Italy).* In: A. Amorosi, B.U. Haq and L. Sabato (Eds.) - Advances in Application of Sequence Stratigraphy in Italy. GeoActa Special Publication, **1**, 55–66.

AMOROSI A., RICCI LUCCHI M., ROSSI V. & SARTI G. (2009) - *Climate change signature of small-scale parasequences from Lateglacial-Holocene transgressive deposits of the Arno valley fill.* Palaeo3, **273**, 142–152.

BELLOTTI P., CHIOCCI F.L., MILLI S., TORTORA P. & VALERI P. (1994) - *Sequence stratigraphy and depositional setting of the Tiber delta: integration of high-resolution seismics, well logs, and archaeological data.* Journal of Sedimentary Research, **64**, 416–432.

BERGAMIN L., DI BELLA L., FREZZA V., DEVOTI S., NISI M.F., SILENZI S., CARBONI M.G. (2006) - *Late Quaternary palaeoenvironmental evolution at the Versilian coast (Tuscany, Italy).* In: Micropalaentological proxies: Proceedings of the Second and Third Italian Meetings on Environmental Micropaleontology-Grzybowski Foundation Special Publications, **11**, 1–11.

DALRYMPLE R.W., BOYD R. & ZAITLIN B.A. (1994) - *History of research, types and internal organization of incised-valley systems: Introduction to the volume.* In: R.W. DALRYMPLE R. BOYD & B.A. ZAITLIN (Eds.) - Incised-Valley Systems: Origin and Sedimentary Sequences. SEPM Special Publication, **51**, 3–10.

GIBLING M.R. (2006) - *Width and thickness of fluvial channel bodies and valley fills in the geological record: a literature compilation and classification.* Journal of Sedimentary Research, **76**, 731–770.

MARIOTTI LIPPI M., GUIDO M., MENOZZI B.I., BELLINI C. & MONTANARI C. (2007) - *The Massaciuccoli Holocene pollen sequence and the vegetation history of the coastal plains by the Mar Ligure (Tuscany and Liguria, Italy)*. Vegetation History and Archaeobotany, **16**, 267–277.

MILLI S. (1997) - *Depositional setting and high-frequency sequence stratigraphy of the Middle-Upper Pleistocene to Holocene deposits of the Roman Basin*. Geologica Romana, **33**, 99-136.

MILLI S., MOSCATELLI M., PALOMBO M.R., PARLAGRECO L. & PACIUCCI M. (2008) - *Incised valleys, their filling and mammal fossil record: a case study from Middle-Upper Pleistocene deposits of the Roman Basin (Latium, Italy)*. In: A. Amorosi, B.U. Haq and L. Sabato (Eds.) - Advances in Application of Sequence Stratigraphy in Italy. GeoActa Special Publication, **1**, 67-87.

VAN WAGONER J.C., MITCHUM R.M., CAMPION K.M. & RAHMANIAN V.D. (1990) - *Siliciclastic sequence stratigraphy in well logs, cores and outcrops: concepts for high resolution correlations of time and facies.* American Association of American Petroleum Geologists, Methods in Exploration 7, Tulsa, U.S.A.

ZAITLIN B.A., DALRYMPLE R.W., & BOYD R. (1994) - *The stratigraphic organization of incised-valley systems associated with relative sea-level change.* In: R.W. Dalrymple, R. Boyd and B.A. Zaitlin (Eds.) - Incised-Valley Systems: Origin and Sedimentary Sequences. SEPM Special Publication, **51**, 45–60.

Ms. received: January 15, 2011
Testo ricevuto il 15 gennaio 2011