

## NOTA BREVE-SHORT NOTE

**THE FOSSIL VERTEBRATE DATABASE OF THE NATURAL HISTORY MUSEUM OF FLORENCE AND HIGH-RESOLUTION MAGNETIC STRATIGRAPHY IN THE UPPER VALDARNO BASIN, AS A CLUE TO DATE OLD COLLECTIONS**ELISABETTA CIOPPI<sup>1</sup> & GIOVANNI NAPOLEONE<sup>2</sup>*Received February 10, 2000; accepted October 11, 2000*

**Key-words:** Fossil vertebrate collections, Data base catalogue, Magnetostratigraphic geochronology, Mid-Late Pliocene, Upper Valdarno, Northern Apennines.

**Riassunto.** La sequenza del Villafranchiano in Italia venne fissata per una parte abbondante sulle associazioni faunistiche provenienti dalle collezioni del Museo di Storia Naturale di Firenze. Le antiche collezioni del Valdarno Superiore (VS) contengono per lo più raccolte di fossili di provenienza stratigrafica indeterminata, o con qualche possibilità di ricostruire la posizione dalle condizioni geologiche dei dintorni. La recente ricostruzione magnetostratigrafica della sequenza sedimentaria del VS ha permesso di riferire i reperti più antichi a ca. 3.0 Ma nel Pliocene medio e quelli più recenti (finora) dei siti di Matassino e Poggio Rosso ed altri della serie della Successione di Montevarchi, a ca. 2.0-1.8 Ma in corrispondenza del crono Olduvai che marca il Pliocene finale. Gli ultimi reperti del Villafranchiano del VS costituiscono l'Unità Faunistica Tasso e sono assegnati al Pleistocene inferiore, ma non sono calibrati con la magnetostratigrafia: tale calibrazione diviene ora possibile anche per le collezioni antiche e mal datate, ed è facilitata dalle informazioni controllabili con l'automatizzazione del catalogo del Museo che fornisce una serie di controlli incrociati di rapida effettuazione. In tal modo, la fauna di Faella e la sezione di Cava Faella sono state le prime ad essere controllate, quando è risultata chiara l'importanza del ruolo che il catalogo può rappresentare, specialmente per le collezioni di età vicina all'Olduvai, poiché in questo intorno sono raggiungibili gradi di definizione estremamente elevati. La datazione numerica è in grado di permettere risoluzioni comparabili tra le vecchie e le nuove collezioni giacché entrambi i tipi di reperti si inquadrano in uno schema unitario rappresentato dalla cronologia delle faune, dall'evoluzione sedimentaria del bacino e dallo sviluppo delle variazioni climatiche regolato dalla scansione dei tempi della magnetostratigrafia.

**Abstract.** The well established biochronologic sequence of the Villafranchian Stage in Italy is mainly based on faunal associations from the Upper Valdarno (UV), mostly collected since the late 18 hundreds, and housed in the Natural History Museum of Florence. The old collections were assembled from mostly unidentified stratigraphic levels, and their position possibly reconstructed from the surrounding geologic features. The recent magnetostratigraphic assessment of the sequence marked the earliest finds at about 3.0 Ma in the mid Pliocene. The end of the Pliocene was recorded by the Olduvai magnetochron, in the Matassino and Poggio Rosso sites, and by other

sparse assemblages. The Tasso Faunal Unit, assembled in the UV, is assigned to the Pleistocene, yet to be clarified by magnetostratigraphic data.

This calibration of old, poorly timed faunas was greatly facilitated by the computer-automated catalogue of the Museum. The possibility of numerous feed-back controls enhanced any contradictory information in fossil collections and made them most fruitful for paleomagnetic calibration: the Faella fauna and the Faella main outcrop are the ones that will be first reexamined. It is in fact now evidenced the potential role of the catalogue for accomplishing the calibration of old findings timed around the Olduvai chron, with an accuracy depending on the available record of their inferred stratigraphic level. Numerical dates will make the old collections comparable to the new ones, as both fitting into a comprehensive framework of faunal chronologies, sedimentary evolution of the UV basin, and development of the Pliocene-Pleistocene climate changes.

**Introduction.**

The first fossil collection of the Natural History Museum of Florence was catalogued in 1845 with the 356 finds from the Upper Valdarno (UV) vertebrates (Azzaroli et al., 1992). While the collection continued to grow, its main purposes remained since focused on determination of taxa and exhibition of the best samples, and minor attention was paid to their geographic and stratigraphic distribution. In the mean time paleontologists, sedimentologists, and geologists found the UV an apt site for development of their theories in reconstructing bulk structures (Merla, 1951) and sedimentary evolution of subsiding basins (Sestini, 1936). All reconstructions of that evolution (Fig. 1) directly involved the biochronologic succession of the fossil remains assembled in the Museum collections, last formalized in the Villafranchian Stage by Azzaroli (1977) and defined in the Mammal Neogene (MN) age classification for the Western Europe.

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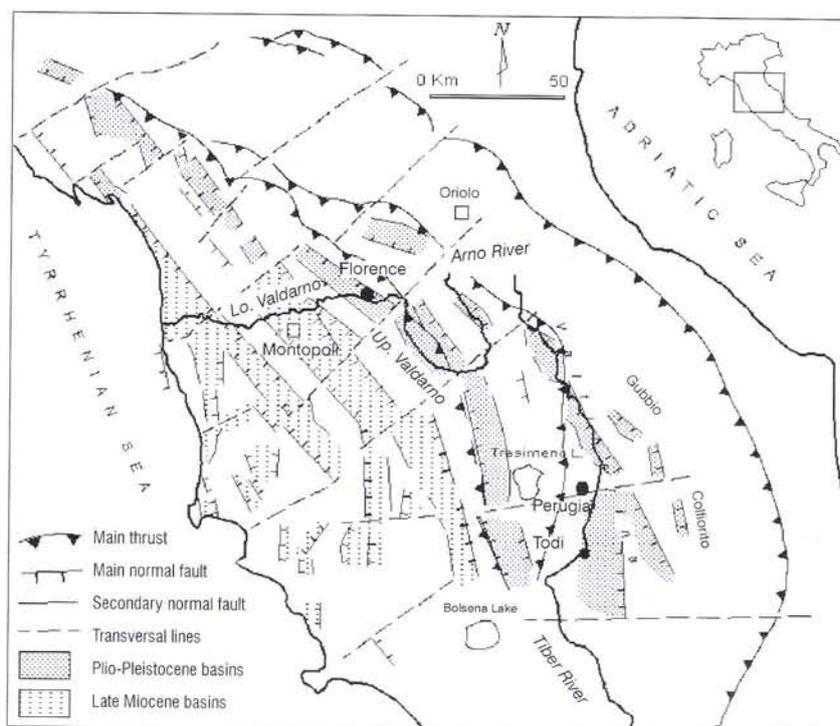


Fig. 1 - Geologic sketch map of the Northern Apennines, and tectonic setting of the extensional basins along the belt, since the Late Miocene (mostly marine basins, in the western areas), and Pliocene and Pleistocene (continental basins, to the east). The NW-SE trend is their typical feature (Modified, after Martini & Sagri, 1993). The continental basins were generally activated in more recent ages, their deposition having started since the Gauss Chron.

New initiatives involved three separate aspects:

1 - Development of the computerized data-base catalogue for the more than 20,000 individual fossil vertebrates in the Museum (Cioppi et al., 1996) which permits automated extraction of data from the entire collection, and provides a ready means of integrating new finds such as those retrieved from the Matassino clay pit in 1964-65 and Casa Frata in 1978 (Borselli et al., 1980), and the latest one at Poggio Rosso in 1995: sites precisely located and completely excavated (Mazzini et al., 1999).

2 - Assessment of the magnetic polarity stratigraphy for the UV continental sequences, first tested on the sediments containing the Matassino deposits (Torre et al., 1993), and then extended down to the lower sequence at the onset of the sedimentation; now the entire UV sequence is going to be analysed, in order to accomplish the other major goal of extending it to the whole 1.5 my time span there recorded.

3 - Continued discoveries of fossil deposits, mostly made by amateurs, with whom a more than 20 year collaboration provided quick information and help in identifying and recovering important finds that in recent years mainly came from the clay pits used by brick factories and for lignite exploitation.

#### The Upper Valdarno faunas and their significance to the Villafranchian Stage.

The faunas used for setting up the biochronologic sequence of the Villafranchian Stage are the classical ones from the Museum collections. The sequence, recently updated by Azzaroli et al. (1986) and Gliozzi et

al. (1997), begins with the Faunal Unit (F.U.) of Triverza (near Asti, north-western Italy), which in the UV lacustrine sediments is represented by the local mammal fauna (l.m.f.) of Castelnuovo dei Sabbioni in the homonymous sequence (Fig. 2).

The following F.U. of Montopoli (in the Lower Valdarno, downstream from Florence) is not represented in the UV but has a key position in the Museum collection. Also the next St. Vallier F.U. and Costa S. Giacomo F.U. are not represented. The new mammal unit showing a major faunal turnover is the Olivola F.U. (established from the Olivola Locality in the north-western Tuscany), which marked the onset of the late Villafranchian: in the UV, its affinities with the Matassino l.m.f. were recognized by Azzaroli (1977).

The last F.U. is that of Tasso, established in the UV by the old findings and roughly reconstructed by inferences from the geologic notes on the catalogue; it was collected from various localities in the uppermost levels of the Montevarchi sedimentary sequence, but mostly in unidentified positions. The fossil deposit discovered in 1978 at Casa Frata (Borselli et al., 1980), was thought to contain close affinities with the Tasso F.U. (De Giulii & Masini, 1986).

The biochronologic assessment made by Azzaroli et al. (1986) confirmed the UV Villafranchian succession with its main events, and the mentioned site of Casa Frata was dated prior to the Tasso F.U., while in the next updating by Gliozzi et al. (1997) the Olivola F.U. differentiated the affinities of the Matassino local fauna by requalifying this latter as transitional between Tasso and Olivola faunas. Although Olivola was retained in the base of the Pleistocene, the Matassino assemblage was

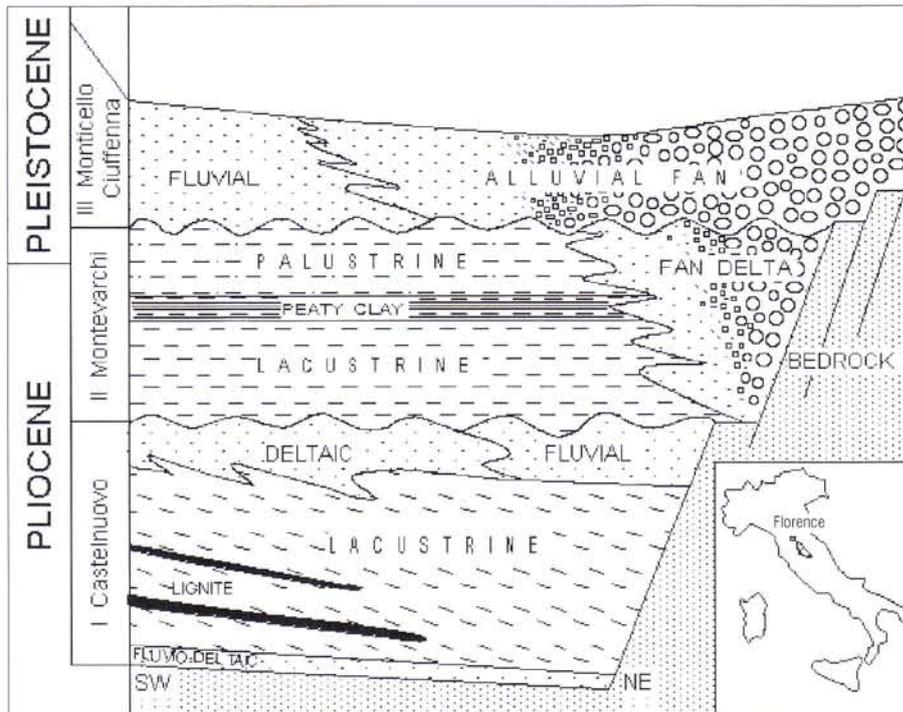


Fig. 2 - Stratigraphic sketch of the UV filling, averaged after the sections that crop out on both river sides (Modified, after Martini & Sagri, 1993).

magnetostratigraphically calibrated as latest Pliocene (Torre et al., 1993). Noteworthy for the UV biochronology and the Museum collections is the significance of the Poggio Rosso large assemblage (recovered in 1995), pending a detailed taxonomic study of this fauna: its stratigraphic position between the Olivola and Tasso faunas identifies it as belonging to the general transition interval between the Pliocene and Pleistocene -an interval of particular interest for the UV.

#### New magnetostratigraphic dating of the Upper Valdarno sequence.

Briefly, the geochronologic updating of the UV mammalian site ages and the environmental evolution of the main sedimentary units follow the three well-established tectono-sedimentary phases, Castelnuovo, Montevarchi, and Monticello Cycles (Fig. 2).

- The earliest sedimentary cycle contains also the onset of the Villafranchian fauna, whose remains were mainly assembled from the lignite-bearing seam in the Meleto Clay at an age close to 3.0 Ma (Albianelli et al., 1997). The Meleto Clay accumulated at changeable rates of continuous deposition almost until the end of the Gauss chron (Fig. 3), missing its final record until the Gauss-Matuyama (G/M) boundary at 2.58 Ma by only 60 ka, as calculated by the magnetocyclic analysis there applied (Napoleone & Albianelli, 1998). During that time the climate underwent a progressive deterioration, from warmer and humid conditions to more temperate ones, starting at about 2.85 Ma, at which spectral analysis of the magnetic signature showed a transition from a

prevailing precessional signal to the onset of obliquity driven climates. No fossil remains in the UV documented this climate crisis. In the Lower Valdarno the Apennine uplift was less effective and the first fauna, the Triversa F.U., showed there a slow evolution toward the faunal assemblage of the following Montopoli F.U. (Dominici, 1994; Benvenuti et al., 1995). This latter, in contrast, was so sharply defined as to represent the onset of the main turnover in the Villafranchian (Azzaroli, 1977); the fossil site was calibrated at the mid/late Pliocene boundary, as it was located just some meter passed the G/M magnetostratigraphic boundary (Lindsay et al., 1980).

- In the second sedimentary cycle the Matassino l.m.f. represented a rather similar variety of species with the Olivola F.U. (Azzaroli, 1977), taken sufficient to mark the beginning of the late Villafranchian and that of the Pleistocene. The Matassino fauna was calibrated in the paleomagnetically surveyed section (Torre et al., 1993), and assigned to the late Olduvai (ca. 1.8 Ma). Therefore, in the UV fossil record, some 0.7-0.8 my time span is missing after the G/M boundary, to be added to the almost 0.4 Ma in the late Gauss unfossiliferous sequence in the upper Meleto Clay. More discussion on that will be reported, while new sites in the UV are examined with the aim to fill the gaps in the magnetostratigraphic reconstruction that presently interrupt the most important continental time series in the Northern Apennines.

At the Olduvai time the record of fossil vertebrates became rich. Besides the Matassino fauna (and the impressive Poggio Rosso deposit, recovered on 1995 higher up in the same clay pit), the nearby Faella area

# UPPER VALDARNO SEQUENCE

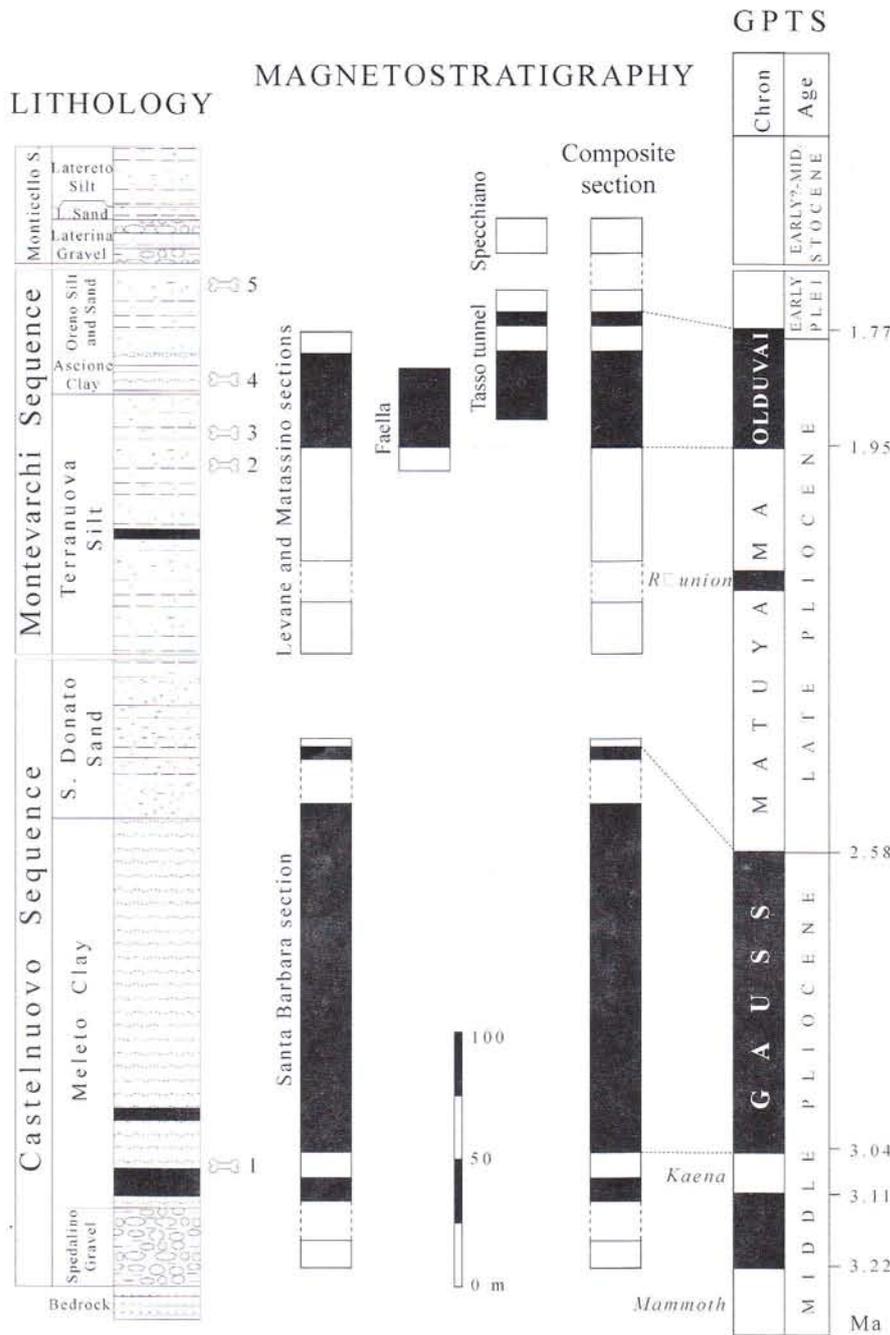


Fig. 3 - Magnetostratigraphic composite of the Pliocene sediments from the UV. The S. Barbara section of lacustrine clays, starting from the basal gravels (ca. 3.3 Ma), contains fossil remains of the Castelnuovo dei Sabbioni l.m.f. (1) in the lignite-bearing layer (ca. 3.0 Ma); no finds are reported until its end (Modified after Albianelli et al., 1997). The composite section of Levane and Matassino (Modified, after Torre et al., 1993) yielded the Matassino l.m.f. (3) and the site was calibrated to the initial Olduvai. In the same section the Poggio Rosso Locality (4) was recovered in 1995 almost on top of the normal polarity. The next section at the Faella clay pit contains the first fossil find (2), dated 1 my later than the last Castelnuovo find. It is marked on the log, but does not represent the newly fixed assemblage of the Faella l.m.f. because this covered the whole sequence. The section labeled as Tasso has the official name of the Tasso railroad tunnel, not to be related to the same name earlier used for the Tasso F.U. assembled in the Museum. No fossils were there found but it exhibited the split terminal Olduvai. The Casa Frata l.m.f. is not yet calibrated. The overall composite, summarizing the present magnetostratigraphic assessment of the Upper Valdarno sequence, is reported along with the GPTS of Berggren et al. (1995).

yielded the older collection to which recent finds were added, such as the deer antler of April 1999. In the Matassino pit, moreover, new finds were recovered stratigraphically above the Poggio Rosso site, until July-August 1999. They were collected from layer beds which can now be correlated with the ones defined in the Faella clay pit, recently surveyed for sedimentology and magnetostratigraphy along new cuts in the section (Albianelli et al. 2000).

The succeeding Tasso F.U. still belongs to the last deposits of the Montevarchi sedimentary cycle with samples collected from the areas around the Tasso creek. But the variety of samples assembled in the Museum old

collections were also with poor paleontological investigations. Such fossil remains, as listed in the catalogue, came from a number of localities whose sediments are generally made by the upper sandy members of the Montevarchi sequence. Whereas some markers suggest that the time span involved could have been rather short, the Tasso F.U. is not as yet calibrated.

- The third sedimentary cycle, Monticello, accumulated by alluvial fans produced by the Arno river meandering when the sedimentary activity moved towards the basin fill; continuity in deposition is difficult to establish. Most sediments accumulated in the basin upstream, and fossil remains were assembled from

the coarser material at a number of localities. Sections for calibration are rather short and less fossiliferous. Some measured ones on the right side of the river yielded a reversed polarity which accounts for a late Matuyama age, that is not younger than almost 0.8 Ma.

Several sections from the higher part of the sequence were recently surveyed for integrated studies on sedimentology and paleomagnetism; preliminary results on the lithostratigraphy showed that a correlation between the uppermost sedimentary bodies can be attained, and their magnetostratigraphy extended through most of the Pleistocene.

#### Dating the fossil collections in the Museum of Natural History.

The geochronologic assessment of the overall sedimentary sequence of the UV Basin has given the framework for dating the faunal associations as well as the main geologic events as bench marks in the history of the basin. When the automated cataloguing of the collections made much more information available to scholars, also individual finds, supplied with sufficient information on their positions in the sequence, could be dated. It made also obvious that the early taxonomic work disregarded the chronologic succession of faunal events, and the biochronologic assessments lacked the time control, which can be now supplied by the study of the magnetic record. From the first evidences one can realize that these UV faunal assemblages cover a broad range of species whose co-existence for more closely defined time intervals could be argued. Catalogue data relative to collections made from different levels of a lithostratigraphic unit demonstrated the large time spans implied in those broad assemblages. Such was the case of the Faella fauna from an area close to the Matassino fossil site, which has now been reconsidered, by simply analysing the catalogue and checking the informations by the automatic controls. It was not even reported as a l.m.f., although its oldest remains with 7 represented species out of the whole set of 12 species there resumed were collected almost two centuries ago. The finds at the bottom of the sequence, April 1999 and January 2000 added the last two species. But its main relevance was to trigger a new approach to the research carried out in the UV on both new acquisitions, the ones from the discoveries in the field and the museal collections. The close marker level of the Olduvai chron represented by the age of 1.95 Ma, and the accumulation rate calculated for similar sequences (Napoleone & Albanelli, 1998) showed a direct way to date a fossil site and with an accuracy of few ky. The decisive effect produced by the automated catalogue was to check the collection specimens labeled as Faella and be able to recon-

struct for it an assemblage, to which also the isolated finds from several important recoveries since the ancient times could be referred (Napoleone et al., 2000).

As a consequence of both types, the new localities discovered in the field at Poggio Rosso and the "localities" represented by the classical collections now "discovered" after long quiescence, the numerical dating was seen quite viable on such an abundant material in the Museum of Florence. New efforts were made to paleomagnetically measure the whole sequence of the Montevarchi complex, and a first major goal performed in dating all of the new finds by an accuracy of few ky. The next goal is here accomplished by realizing that the same use of the magnetic stratigraphy can be extended to the old collections for the well located samples. By means of this step, all specimens from the new and old fossil sites will represent the key data for re-examining the old collections, being well constrained in their positions by magnetostratigraphy. The paleontological control is aimed at identifying the affinities in the systematics that new and old samples of defined provenance have with the classical ones of undefined positions in the collections, which often represent the holotypes of the most important reconstructions of faunal groups (Azzaroli, 1992).

This presently appears quite easy to realize in terms of ky, the lapse of time being almost 150 ky, as quantified from the detailed magnetostratigraphy of the sequence through the section of the Faella clay pit. But knowing that most sites in the Museum collections lack accurate geographical and stratigraphical indications, and the lithologic units are quite thick and sometimes repetitive, one must make allowance for a considerable time-span for most "assemblages". Rigorous stratigraphic discrimination was available for only three localities which have produced good stratigraphic references: Matassino, Casa Frata and Poggio Rosso. These units, thence, when fully dated by the paleomagnetic calibration, will assume an important role, and the environmental significance of their faunas be related to well defined time spans.

#### Discussion and conclusions.

The development of a new trend in the research work that the Museum experienced in recent years was triggered by the occasional find of the Poggio Rosso Locality. It will add important improvements to our knowledge of the UV history after the restoration be completed and the paleontological studies ready, so to fit the biochronologic ages established from the old collections. Together, such an event and the museal base fit the newly established magnetostratigraphy of the UV sedimentary sequence. The result of such a combination will drive on the Museum collections decisive insights

that can make several of them datable in the geochronologic system as updated by the numerical time scale. This will represent a drastic turnover in the aims of the biochronologic studies on the UV, based on the long lasting tradition of using the museal collections to discover evidences for successive evolutionary steps developed as osteologic differences. Still, though, directly connected with the Museum specific activities of keeping track of the past evidences of life in the UV. The acquaintance maintained with the old rich collections, by taking care of their enrichment, and updating and using the new cataloguing systems, yet complaining the lack of information produced in the past by the little accuracy in collecting fossils, was, in our opinion, the first condition which led to the expected new discoveries. A second condition was that now the details, observed on a collection by using the automated catalogue and checked by the feed-back procedures made available by rapid controls, can be referred to new biochronological associations with a marked position in the MN scale, as they are assembled by "excavating" in the old collections with the computerized catalogue. The third one is given by magnetostratigraphically dated faunal associations which can provide dates to the "new finds" recovered in the Museum collections by means of the new use of the automated catalogue.

New developments at the Natural History Museum of Firenze thus come together in a focus on the UV Basin and its potential contribution to the understanding of the Plio-Pleistocene history. The computerized system of the collections provided a great deal of information which will fill gaps in the environmental and biochronologic reconstructions.

The results of several calibrated sections and faunal sites are ready and can be partly used here for updating the relative positions of the established biochronologic reference units. It had been calculated, from the early-Castelnuovo fauna (Fig. 3, fossil site 1) of the Triversa F.U. and the Lower Valdarno succession which spans the Triversa-like fauna before the age of the Montopoli F.U., that these faunas contain time intervals spanning some hundreds of ky. In contrast, the three localized fossil deposits of Matassino, Poggio Rosso, and Casa Frata (Fig. 3, fossil sites 3-4-5) will be firmly dated by their magnetic stratigraphy; thence their biochronologic affinities with the confining mammal units will solely depend upon the available time control. Without it, the affinity of Matassino with Olivola was maintained by Azzaroli et al. (1986), while Gliozzi et al. (1997) still placed the Olivola time in the Pleistocene.

A consideration would be made on the Matassino section. It was magnetostratigraphically calibrated as the end of the Olduvai chron (Torre et al., 1993), and the age of its l.m.f. had to be shifted back to the Pliocene.

Accordingly, the beginning of the late Villafranchian late Pliocene - a fact yet to be mentioned in the related paleontological literature. This highlights the importance of the new fossil site at Poggio Rosso, first noted in the same Matassino sequence and possibly of the same latest Pliocene age, because of its magnetic signature of Olduvai age.

Paleomagnetic calibration now represents a new and detailed base for the UV chronology; it was disregarded soon after the first attempts, made at the Matassino clay pit in 1993. There it showed that the Matassino l.m.f. had an age quite older than it was thought before, and therefore it implied a reappraisal of the Olivola established position in the Pleistocene. The updating of the biochronologic data made since that of Azzaroli et al. (1986) has not really produced a new deal for the MN age classification during the mid Pliocene to mid Pleistocene. The affinity of Matassino with Olivola was only shifted to younger ages when it was interpreted as transitional between Olivola and Tasso (Gliozzi et al., 1997), or further younger when it seemed to show an affinity with the Tasso F.U. (Masini et al., 1998), while waiting for its magnetostratigraphic assessment.

Besides the importance of all mentioned improvements on precisely timing the new individual finds, which anyhow represent spots in the geochronology of the UV, the major goal attained by the overall updated results will be represented by the great potentiality to assign an age to the collections. These were assembled from a number of finds in different stratigraphic positions and now synthesize time intervals which can be measured in the identifiable positions. The primary relevance of the catalogue is to greatly facilitate this identification; it can allow recognition of new associations which were never studied but will now represent the reference for new finds.

The conclusion of the integrated results is the numerical dating of the Museum collections as a direct consequence of the acquaintance with the old collections, having stressed the importance of complete recording of informations while recovering fossil remains. Better surveying on the main sequences in order to correlate their litho-sedimentary features led to improve systematically the occasions of new finds. The newly discovered fossil deposit of Poggio Rosso and its great potential relevance for the recognition of the faunal changes round the Plio-Pleistocene boundary caught much of the Museum activities during last years. Together the museal activities were devoted to preparing more than 1,000 specimens for the study collections, performing exhibitions all over Italy, and the research interests focused on timing both collection types, the recent ones from the recovered sites and the classical old ones, newly "discovered" in the Museum patrimony.

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