1. INTRODUCTION

Since the 19th century, the Villafranchian succession cropping out in the Barga and Castelnuovo Garfagnana basins (Tuscany) was investigated due to its fossil record, mainly represented by vegetable and mammal remains. The paleontological data increased as a consequence of the lignite and clay vegetable and mammal remains. The paleontological studies and limited number of vertebrate remains (De Stefani, 1887 and 1889; Ugolini, 1902; Zaccagna, 1932 and Masini, 1936), the Villafranchian age of this succession is accepted.

The main lithological features of these deposits have been described, among the others, by Nardi (1961) and Calistrì (1974), and mapped at 1:10,000 scale by Nardi et al. (1986 and 1987). Unfortunately, these papers were not supported by detailed lithostratigraphic and sedimentological studies. Nevertheless, based on the significant lignite contents of the fine grained basal sediments and the dominant coarse grained overlying deposits, the whole succession was interpreted as a fluvial-lacustrine cycle. Recently, lithostratigraphy and facies analysis of these deposits was investigated by Puccinelli et al. (in press, a) and Landi et al. (2002-2003), respectively. On the basis of these studies, the main lithostratigraphic and sedimentary features of the Villafranchian formations, discontinuously exposed in the Barga and Castelnuovo Garfagnana areas, will be described in this paper.

A similar succession, divisible in two formations, crops out north-westward in the Aulla-Olivola and Pontremoli tectonic depressions (Bertoldi, 1997 and...
Bernini et al., 1990). Mainly consisting of fine grained lithofacies with medium to thick coarse grained interbeddings, the “Argille, sabbie e conglomerati di Aulla” (Puccinelli et al., in press, b) is characterized by a variable amount of centimetric to decimetric lignite fragments and organic-rich horizons. It is overlain by the coarse grained “Conglomerati di Olivola” (Puccinelli et al., in press, b), characterized by subordinate fine grained interbeddings.

2. GEOLOGICAL SETTING

The investigated area (Fig. 1) is one of the continental intermontane tectonic basins, that opened as a consequence of the counter-clockwise migration of the chain-foredeep-foreland system and of the extension of the Northern Apenninic Tyrrhenian margin (Meletti et al., 1995 and references therein) during the Late Ruscinian/Early Villafranchian time interval (Bernini et al., 1990; Bertoldi, 1995 and 1997).

Roughly comprised between the Apuan Alps and the Apenninic watershed, the studied area includes two tectonic depressions, 5 Km wide and 10 (Barga) to 15 Km (Castelnuovo Garfagnana) long, separated by the so-called “Mt. Perpoli high” (Soglia di Monte Perpoli of Puccinelli, 1987). These depressions are related to the movement of tectonic blocks collapsed and rotated along antithetical faults and interpreted as half-graben, with the master faults plunging towards the Tyrrhenian border (Martini & Sagri, 1973; Eva et al., 1978).

The Villafranchian succession laid down in the Barga and Castelnuovo Garfagnana depressions unconformably overlies sedimentary successions of the Apennine thrust-and-fold belt, here represented by the Falda Toscana (mainly with the Macigno Formation), Canetolo and Ottone Units. Along the western sides of both depressions, the Falda Toscana in turn tectonically overlies the Methamorphic Core Complex of the Apuan Alps.

3. PREVIOUS STUDIES AND INFERRED AGE

The sedimentary succession, cropping out in the Barga and Castelnuovo Garfagnana areas, was investigated entirely by few authors. Among them, De Stefani (1887 and 1889), Zaccagna (1917 and 1932), Ugolini (1902), Masini (1932 and 1936), Tongiorgi & Trevisan (1953), Azzaroli (1955), Nardi (1961 and 1965) and Calisti (1974) focused on stratigraphy, even if only this latter studied the entire Villafranchian sedimentary succession. The papers of Bartolini & Bortolotti (1971), Nardi (1961 and 1965), Nardi et al. (1986 and 1987), D’Amato Avanzi & Puccinelli (1988), Puccinelli (1987), Dallan et al. (1991) and Moretti (1990) mainly deal with neotectonics and/or landslide hazard.

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Fig. 1 - Tectonic sketch of the Northern Apennines and location of the main intermontane tectonic depressions nearby the study area (within the square).  
Schema strutturale dell'Appennino settentrionale con la localizzazione delle principali depressioni tettoniche limitrofe all'area di studio (nel riquadro).
Unfortunately, the paleontological data as well as the age-significant fossil remains are scarce (Tab. 1). However, the mammal fragments and the presence (Landi et al. 2002-2003) of some molluscs (Laminifera villafranchiana, Prososthenia paulae, Theodoxus cf. groyanus) and characean species (Nitellopsis cf. Megarenis - Carnevale et al., 2003) point to (according to Azzaroli, 1977 and De Giuli & Masini, 1983) a Lower-Middle Villafranchian age for the “Argille, sabbie e conglomerati di Fornaci di Barga” and allow to assign the overlying “Conglomerati di Barga” to Late Villafranchian.

Tab. 1 - List of vertebrate fossils remains from the “Argille, sabbie e conglomerati di Fornaci di Barga” and “Conglomerati di Barga” formations.

<table>
<thead>
<tr>
<th>Authors</th>
<th>Localities</th>
<th>Fossil remains</th>
<th>Formations</th>
</tr>
</thead>
<tbody>
<tr>
<td>De Stefani (1889)</td>
<td>Barga</td>
<td>Equus stenonis</td>
<td>Conglomerati di Barga</td>
</tr>
<tr>
<td>Meneghini (1880)</td>
<td>Ghivizzano</td>
<td>Tapirus</td>
<td>Hystrix</td>
</tr>
<tr>
<td>De Stefani (1889)</td>
<td>Fornaci di Barga</td>
<td>Rhinoceros etruscus</td>
<td></td>
</tr>
<tr>
<td>De Stefani (1889)</td>
<td>T. Loppora</td>
<td>Rhinoceros etruscus</td>
<td>Sus arvernensis</td>
</tr>
<tr>
<td>Ugolini (1902)</td>
<td>Fornaci di Barga</td>
<td>Tapirus arvernensis</td>
<td>Cervus pardinensis</td>
</tr>
<tr>
<td>Masini (1936)</td>
<td>Fornaci di Barga</td>
<td>Mastodon arvernensis</td>
<td></td>
</tr>
<tr>
<td>La Fossa</td>
<td>Emys sp.</td>
<td>Tapirus sp.</td>
<td>Sus sp.</td>
</tr>
<tr>
<td>De Stefani (1887)</td>
<td>Custia</td>
<td>Mastodon arvernensis</td>
<td></td>
</tr>
<tr>
<td>Fornaci del Ponte Castiglione</td>
<td>Cervus sp.</td>
<td>Mastodon arvernensis</td>
<td>Tapirus sp.</td>
</tr>
<tr>
<td>Fornaci del Bianchi</td>
<td>Tapirus sp.</td>
<td>Sus arvernensis</td>
<td></td>
</tr>
<tr>
<td>Ugolini (1902)</td>
<td>T. Loppora</td>
<td>Tapirus arvernensis</td>
<td>Cervus pardinensis</td>
</tr>
<tr>
<td>Masini (1932)</td>
<td>Mastodon arvernensis</td>
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<td></td>
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</tbody>
</table>

4. LITHOSTRATIGRAPHY AND SEDIMENTARY FEATURES OF THE MAPPED FORMATIONS

As it is well known, the continental successions cropping out in the intermontane, post-collisional basins are usually badly exposed, due to both the large diffusion of the anthropic activities (e.g. agriculture, urbanization) and vegetation cover. Consequently, the vertical and/or lateral outcrop extension is often limited, and the geometric and stratigraphic relationships between formations overshadowed. However, based on some well exposed sections, the entire succession has been rather well reconstructed.

In the study areas, most significant sections are located in the Barga area, where the mapped formations and the boundary between them are also well exposed. According to previous papers (Nardi et al., 1986 and 1987; Dallan et al., 1991), in the investigated area two formations have been recognized, and named by Puccinelli et al. (in press, a): “Argille, sabbie e conglomerati di Fornaci di Barga” (AFB) and “Conglomerati di Barga” (PLB). In the Castelnuovo Garfagnana area, within PLB, the Mt. Alfonso member is distinguishable. The extension of both formations (AFB+PLB) is represented in Fig. 2.

4.1. Argille, sabbie e conglomerati di Fornaci di Barga (Puccinelli et al., in press, a)

Synonymies

Argille azzurre lignitifere e sabbie ocracee (Nardi, 1961)
Argille di Fornaci di Barga pro parte (Calistri, 1974)
Sabbie e argille lignitifere (Nardi et al., 1986)
Argille e sabbie lignitifere (Nardi et al., 1987)
Formazione di Fornaci di Barga (Catanzariti et al., 2002)
Lithostratigraphic Unit 1 (Landi et al., 2002-2003)

Significant outcrops (see Tab. 2)

Fig. 2 - Schematic geological map of the Barga and Castelnuovo depressions and nearby areas, based on the Geological Map at 1:50,000 - Sheet 250 Castelnuovo Garfagnana (Puccinelli et al., in press, a) and on some geological maps at 1:10,000 scale (Nardi et al., 1986 and 1987; Dallan et al., 1991).

Carta geologica schematica dei bacini di Castelnuovo Garfagnana e Barga e delle aree limitrofe, basata sulla Carta Geologica a scala 1:50.000 - Foglio 250 Castelnuovo Garfagnana (Puccinelli et al., in press, a) e su alcune carte geologiche a scala 1:10.000 (Nardi et al., 1986 and 1987; Dallan et al., 1991).
**AFB** mainly consists of fine (clayey to sandy) grained lithofacies interbedded by medium to coarse conglomerate (from channel to wedge or sheetlike shaped), that sometimes can be dominant. The formation is also characterized by a variable amount of centimetric to decimetric lignite fragments, that in places are abundant and concentrated in organic-rich horizons (Fig. 3a).

The fine grained deposits, ranging from 0.5 to 3-7

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Tab. 2 - Most significant outcrops in the Barga and Castelnuovo Garfagnana depressions of the “Argille, sabbie e conglomerati di Fornaci di Barga” and “Conglomerati di Barga” formations. Exposed lithofacies are also synthetically described.


<table>
<thead>
<tr>
<th>Localities</th>
<th>Member (Mb.) Lithofacies (Lt.)</th>
<th>Formations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Barga area</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T. Loppora</td>
<td>Lenticular-shaped conglomerate (Lt.) channel-shaped conglomerate (Lt.)</td>
<td></td>
</tr>
<tr>
<td>Rio Latrani</td>
<td>Sheet-like conglomerate (Lt.)</td>
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<tr>
<td>Rio Zanesi</td>
<td>Sheet-like conglomerate (Lt.)</td>
<td></td>
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<tr>
<td>Corsonna</td>
<td>Fine grained (Lt.) &amp; channel-shaped conglomerate (Lt.)</td>
<td></td>
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<tr>
<td>Le Palmente</td>
<td>Lenticular-shaped conglomerate (Lt.) &amp; sandy (Lt.)</td>
<td></td>
</tr>
<tr>
<td>Casa Volpaia</td>
<td>Fine grained (Lt.) and organic-rich horizons &amp; channel-shaped conglomerate (Lt.)</td>
<td></td>
</tr>
<tr>
<td>Pieve di Loppia-Barga road</td>
<td>Lenticular-shaped conglomerate (Lt.) &amp; sandy (Lt.)</td>
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<tr>
<td>Barga</td>
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<tr>
<td><strong>Castelnuovo G. area</strong></td>
<td></td>
<td></td>
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<tr>
<td>Rio Dezza</td>
<td>Mt. Alfonso (Mb.). Poorly sorted conglomerate</td>
<td></td>
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<tr>
<td>Il Colle</td>
<td>Mt. Alfonso (Mb.). Poorly sorted conglomerate</td>
<td></td>
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<tr>
<td>Mt. Alfonso</td>
<td>Mt. Alfonso (Mb.). Poorly sorted conglomerate</td>
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<tr>
<td>S. Lucia</td>
<td>Lenticular-shaped conglomerate (Lt.) &amp; sandy (Lt.)</td>
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<td>Castegna</td>
<td>Lenticular-shaped conglomerate (Lt.) &amp; sandy (Lt.)</td>
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<tr>
<td>Soffiana</td>
<td>Sand and silty (Lt.) &amp; rare organic-rich horizons</td>
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<tr>
<td>Bamborino</td>
<td>Lenticular-shaped conglomerate (Lt.) &amp; sandy (Lt.)</td>
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<tr>
<td>Liana</td>
<td>Sandy (Lt.) &amp; lenticular shaped conglomerate (Lt.)</td>
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<tr>
<td><strong>Barga area</strong></td>
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<tr>
<td>Rio Secco</td>
<td>Fine grained (Lt.) &amp; channel-shaped conglomerate (Lt.)</td>
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<tr>
<td>Cava Fornaci</td>
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<td>Le Palmente</td>
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<td>Rio Cavo</td>
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<td>Rio Zanesi</td>
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<td>Rio Val di Lago</td>
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<td>Corsonna</td>
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<tr>
<td>Rio della Giuvicchia</td>
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<tr>
<td>Casa Volpaia</td>
<td>Fine grained (Lt.) &amp; channel-shaped conglomerate (Lt.)</td>
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<tr>
<td><strong>Castelnuovo G. area</strong></td>
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<tr>
<td>Rio Dezza</td>
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<tr>
<td>Rio la Fossa</td>
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<tr>
<td>Collemandina</td>
<td>Fine grained (Lt.) &amp; sandy (Lt.)</td>
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<tr>
<td>Bamborino</td>
<td>Fine grained (Lt.)</td>
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<tr>
<td>La Bottegaccia</td>
<td>Fine grained (Lt.) &amp; organic-rich horizons</td>
<td></td>
</tr>
<tr>
<td>Gamberone</td>
<td>Fine grained (Lt.), organic-rich horizons &amp; sandy (Lt.)</td>
<td></td>
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<tr>
<td>Antisciana</td>
<td>Fine grained (Lt.) &amp; channel-shaped conglomerate (Lt.)</td>
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<tr>
<td>Belvedere</td>
<td>Fine grained (Lt.) &amp; channel-shaped conglomerate (Lt.)</td>
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</tr>
<tr>
<td>Rio Valardino</td>
<td>Fine grained (Lt.) &amp; channel-shaped conglomerate (Lt.)</td>
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</tbody>
</table>
m in thickness, are usually organized in centimetric to decimetric rhythmical alternance of grey-dark, grey to bluish or violet clay to silty-clay and yellowish silt or sandy beds, with horizontal to cross or through lamina-
tion, in places well evidenced by small lignite frag-
ments. They can be associated with 0.5 to 3.5 m thick
massive to horizontal laminated organic-rich clay or
silty to sandy interbeddings, that somewhere show soft
deforation structures. The organic-rich levels, more
abundant in the lower portion of the formation, contain
scattered lignite fragments, that can concentrate in 20
to 40 cm thick horizons, with limited (10-15 m) lateral
extent. The sandy intervals, usually 10-20 cm thick and
up to 1.5-2 m wide, can be up to 1.5 m thick and 10 m
wide. In the thickest sandy levels, thin to medium thick
cobble- to rounded cobbles and lenses. This medium to coarse
coregrained massive and silt- to clast-supported conglomer-
ate mainly made of clasts referable to the Macigno Fm. (i.e.
very coarse grained, monomictic, massive conglomerate,
interbedded, at different levels, with medium/coarse to
fine matrix, not always present. This deposit, with weak
sorting and limited (3-5 to 15-20 m) lateral extent, ranges from 1 to 3 m in thickness.

The coarse grained lithofacies can also be repre-
sented by an alternance of clast-supported, wedge-
to sheet-like conglomerate or sandy conglomerate, and
medium to coarse sand. This conglomerate, from 1 to 3
to coarse sand. This conglomerate, from 1 to 3 m thick and up to 20-40 m wide, lacks any evidence of
basal erosive surface. The pebbles and cobbles range from sub-angular to sub-rounded/rounded. The medium
to coarse sandy matrix is present in variable amount,
that can vary in percentage at metric scale. The sandy
interbeds range from massive to cross laminated.

In both types of conglomerate, the clasts are
mainly represented by unmetamorphosed lithotypes,
with the arenaceous clasts (referable to the Macigno Fm.)
being more abundant than the carbonatic ones. In
places, the arenaceous clasts can be dominant. The
metamorphic (Landi et al., 2002-2003) ones are more
abundant in the Barga (up to 15-20%) than in the
Castelnuovo Garfagnana area, where they are extre-

Scattered along the Apenninic border, AFB is
interbedded, at different levels, with medium/coarse to
very coarse grained, monomictic, massive conglomerate,
mainly made of clasts referable to the Macigno Fm. (i.e.
Units 3 and 4 of Landi et al., 2002-2003). This unsorted
to poorly sorted, matrix- to clast-supported conglomer-
ate is nicely exposed at Colle Buvicchia and Mologno. It
chiefly consists of sub-angular to rounded cobbles and
boulders, in places well imbricated. The medium to coarse
sandy matrix is furnished by the Macigno Fm.

weathering. Ranging in thickness from few metres up to
100 m, such coarse clastic wedges (in places) can
represent the entire Villafranchian sedimentary record.

According to Landi et al. (2002-2003), the assocation
of fine and coarse grained lithofacies with in situ
accumulated organic matter (mainly represented by
lignite) was sedimented in a braided fluvial system,
referred to an anabranching organo-clastic substage
(sensu Nanson & Knighton, 1996), flowing from
Castelnuovo Garfagnana to Barga. It interferes with
the alluvial fan deposits (dominated by debris-flow pro-
cesses), cropping out along the Apenninic border (i.e.
Units 3 and 4 of Landi et al., 2002-2003), and develops
transversally to the tectonic depression axis.

The thickest exposures range from 10-40 to 80 m
in the Barga area and from 10 to 30-40 m in the
Castelnuovo Garfagnana area. The maximum thickness
of this formation measured near Castelnuovo Garfagnana,
including a drilled portion, can reach 200 m (De Marco & Caielli, 1995; Cancelli et al., 2002).
Usually, the outcrops are not thicker than 10-30 m in
Barga as well as in Castelnuovo Garfagnana areas.

The unconformable contact with the underlying
formations is exposed in few localities, with bad expo-
sure conditions and very limited lateral extent. Along
the eastern border of the Barga depression, the
Macigno Fm. is topped by the basal coarse grained and
poorly sorted conglomeratic lithofacies of AFB. In the
boreholes drilled near Villa Collemandina, the substra-
tum (represented by Ligurian successions) has been
reached below 90-100 m of AFB.

The AFB/PLB contact is frequently well exposed
and characterized by an abrupt facies change, sugge-
ting a possible disconformity surface. Nevertheless, in
some places (Gallicano and Barga areas) the hetero-

topy between the two formations is not excluded. In fact,
conglomeratic interbeddings are locally present in the
uppermost part of AFB; they are similar to those inter-
bedded in the lowermost part of PLB. In other areas,
AFB is topped by the erosive post Villafranchian coarse
grain terraced deposits. According to the quoted foss-

il remains, the lowermost portion of this formation
could be assigned to the Lower Villafranchian, whilst its
upper portion could reach the Middle Villafranchian.

4.2. Conglomerati di Barga (Puccinelli et al., in press, a)

Synonyms
Ghiaie con prevalenza di rocce mesozoiche e meta-

morfiche (Nardi, 1961)
Ciottoli e sabbie di Loppia (Calisti, 1974)
Conglomerati a ciottoli prevalentemente calcarei
(Nardi et al., 1986)
Ghiaie e conglomerati calcarei (Nardi et al. 1987)
Conglomerati di Barga (Catanzariti et al., 2002)
Lithostratigraphic Unit 2 (Landi et al., 2002-2003)

Significant outcrops (see Tab. 2)
Barga: T. Loppora, Rio Latrani, Rio Zanesi, Le Pal-
mente, Pieve di Loppia-Barga road, Barga and Casa
Volpiaia.
Castelnuovo Garfagnana: Bamborino, Rio Dezza, Il
Colle, S. Lucia, Castagni, Soffiana, Mt. Alfonso and
Liana.
Fig. 3 - Main lithological features of the "Argille, sabbie e conglomerati di Fornaci di Barga" Fm. (A) and of the "Conglomerati di Barga" Fm. (B).

Colonne stratigrafiche mostranti le principali caratteristiche litologiche delle “Argille, sabbie e conglomerati di Fornaci di Barga” (A) e dei “Conglomerati di Barga” (B).
PLB is characterized by the dominance of medium to coarse (from pebbles to cobbles) grained lithofacies, whilst sandy to silty-clayey levels, with very rare paleosols, are subordinate. Though texture, sedimentary structures and shapes of the conglomerate can change even at metric scale, two end-members can be described: one shows sheet-like geometry and significant presence of sand interbeddings, the other is lens-shaped and characterized by erosive basal surface and small amount of matrix (Fig. 3b).

The sheet-like, clast-supported conglomerate, with massive to crude bedding is interbedded with thin (2-3 to 5-10 cm), massive to horizontally stratified, lenticular yellowish sand. These coarse grained intervals, with very rare sedimentary structures, mainly consist of poorly to moderately sorted conglomerate, with well rounded pebbles and cobbles, rarely imbricated and with a variable amount of sandy-silty to silty matrix; the matrix percentage may change even within the same interval. This disorganized to poorly organized conglomerate, frequently ranging in thickness from 0.5 to 1 m, can be up to 3 m thick and 20-30 m wide.

The lens-shaped, medium to coarse conglomerate, is chiefly composed of well sorted clasts and small percentage of silty to sandy matrix. The sub-rounded to rounded clasts are frequently imbricated and the matrix can be, in places, either absent or significantly present. This conglomerate, sometimes channelized, shows weakly erosive basal surface and planar to trough cross stratification. Ranging in thickness from 0.5 to 3 m, it can be up to 20-30 m wide. Within this conglomerate, thin to thick (10-50 cm) interbeddings of massive, brownish to brown-reddish sand, with small lateral extension, are present.

In both types of conglomerate, the clasts are chiefly represented by non-metamorphic or metamorphic carbonatic lithotypes; whilst sandstone (referable to the Macigno Fm.) is subordinate. Within the coarse grained lithofacies, interbeddings of silt and fine to medium grained yellowish to reddish sand, up to 1 m thick, are present. More abundant in the sheet-like conglomerate and sometimes bioturbated, silt and sand frequently show through and planar cross-beding. In places, grey to dark-grey, millimetric to centimetric lenses of clay evidence the sedimentary structures of these fine grained interbeddings.

PLB is also characterized by the occurrence of centimetric to decimetric rhythmical interbeddings of grey clay or silty-clay to sandy beds, with horizontal to cross or through lamination, similar to those described for the underlying formation. These fine grained lithofacies, usually ranging from few decimetres to 1-2 m (Rio Latrani, Rio Sartoiani, T. Giuvicchia and T. Corsonna), are up to 20 m thick at Casa Volpaia. In the silty-sandy or sandy beds micro and macro vegetable remains may concentrate but are at different levels, centimetric to decimetric dark grey or blackish paleosols are also present. In all quoted localities, the heteropic transitions with the coarse grained deposits are visible.

As reported by Landi et al. (2002-2003), the described lithofacies association is dominated by conglomerate together with sandy lenses and centimetric to decimetric alternance of fine grained deposits (characterized by organic-rich horizons and paleosols). This association is referable to a gravel bed-load braided river system, flowing from NE to SW (i.e. from Castelnuovo Garfagnana to Barga).

As described for AFB, along the Apenninic border, also PLB, interdigitated with coarse grained lithofacies (Unit 3 of Landi et al., 2002-2003), characterized by sub-angular to rounded (the boulders) clasts, chiefly consisting of sandstone (referable to the Macigno Fm.), and interpreted as coalescent alluvial fan deposits (dominated by debris-flow processes) developed transversally to the tectonic depression axis.

PLB is superexposed along the oriental side of the Serchio Valley, and ranges in thickness from 70 (Gallicano) to 170 m (Barga). The better exposures are located between Loppia and Barga and in the Villa Collemandina area. Usually, the outcrops can be 20-40 m thick and from 100 to 200 m wide. The clearly erosive contact between the Conglomerati di Fornaci di Barga and the post Villafranchian coarse grained terraced deposits is frequently well exposed. According to the few listed paleontological remains, this formation could be assigned to the Middle to Late Villafranchian.

West of the Castelnuovo Garfagnana area, PLB is represented by medium to coarse clast-supported conglomerates of Mt. Alfonso member (Unit 5 of Landi et al., 2002-2003). Showing a tabular geometry with thickness ranging from 0.5 to 3 m, these deposits can vary even in a short distance from disorganized to organized sedimentary body. The poorly sorted clasts, with a diameter up to 50 cm, in places imbricated, are mainly composed of carbonate, whilst the presence of sandstone is subordinate, though sometimes it can be significantly present. The 100 (westward) to 40 m (eastward) thick Mt. Alfonso member is interpreted as a braided fluvial fan, supplied by the Apuan Alps and developed transversally to the basin axis (Landi et al., 2002-2003).

5. CONCLUSIVE REMARKS

On the basis of the main lithostratigraphic and sedimentological features of the described Villafranchian succession, the following points should be emphasized.

- In the Barga and Castelnuovo Garfagnana areas, AFB and PLB are characterized by distinctive lithofacies associations, and the boundary between the two formations is quite easily recognizable.
- Within AFB, clay and conglomerate are subordinate and the formalized name points out the wide lithological spectrum, that characterizes this formation. Nevertheless, lateral and vertical variations between fine grained and coarse grained lithofacies are distinguishable at outcrop scale, but hardly mappable, due to their limited thickness and lateral extent.
- The clayey intervals of AFB are more widespread and thicker in the Castelnuovo Garfagnana than in the Barga depression, whilst sandy intervals are thicker and wider in the Barga than in the Castelnuovo Garfagnana area. Thin to very thin and well stratified, clayey-silty to sandy laminated (varve-like) intervals are peculiar of the Castelnuovo Garfagnana area.
- The organic-rich horizons within AFB are relatively more abundant in the lower portion of the formation. They are usually represented by centimetric to decimetric horizons within the fine grained portions. The largest fragments of lignite and the chunks of trees...
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are scattered throughout the formation, and some of these latter are sometimes still in life position. The lignite banks, including the mined ones, are thicker and more continuous than those cropping out or mined in the Barga area.

- In AFB the coarse grained intervals are mainly represented by channelized conglomerate interbedded by clayey-silty or sandy dominant lithofacies. Likewise, the sheetlike conglomerate (almost absent in the Castelnuovo Garfagnana area), present in the lower portion of the formation, is associated with clayey-silty or sandy lithofacies.

- In spite of the lateral and vertical lithological variation of the different lithofacies, the dominance of the coarse grained conglomerate allows the easy mapping of the PLB, also characterized by sandy interbeddings. Silty-clayey to sandy fine grained lithofacies (with thin organic-rich horizons similar to those present in AFB), with reduced thickness as well as lateral extent, are clearly in heteropy to the conglomerate. Also in the Castelnuovo Garfagnana area these lithofacies (including organic-rich horizons) are very limited in thickness and lateral extension.

- Lignite fragments or other biogenic remains, as well as paleosols, are extremely rare and scattered within PLB. Indeed, large lignite fragments can be present within the coarse grained lithofacies, whilst millimetric to centimetric lignite flakes are relatively more frequent within the finest grained lithofacies.

- In the Castelnuovo Garfagnana depression, within the PLB, the Mt. Alfonso member is distinguishable. Mainly consisting of polymictic, poorly sorted medium to coarse conglomerate and subordinate coarse grained sand, it can be correlated with the conglomerate cropping out in the Gallicano area (D’Amato Avanzi & Puccinelli, 1988) and mapped within the PLB.

- In spite of similar lithologies present in both formations, the lithofacies assemblages point out the superposition of gravel bed-load braided river deposits (PLB) on cohesive sediment anabranching river deposits (AFB). Both successions interfinger with the alluvial fan conglomerate, that in places can represent the entire Villafranchian succession.

- The abrupt facies change between these two clastic successions can be interpreted as a disconformity surface (Landi et al., 2002-2003). Unfortunately, it is neither supported by paleontological data nor confirmed by other field evidence. However, the conglomeratic lithofacies interbedded within the AFB shows neither a polarity towards the top of the formation nor significant similarities with the coarse grained lithofacies of the PLB.

- On the other hand, the erosive contact between AFB and PLB can be also interpreted as stratigraphic, because erosive surfaces are frequent within this type of deposits (from anabranching to gravel bed-load braided). Moreover, the presence of channelized conglomeratic lenses within the uppermost part of the AFB, similar to those present in the overlying lowermost part of PLB, can support (at least in some places) a quite sharp but transitional boundary between AFB and PLB (Puccinelli et al., in press, a).

- In summary, though the Villafranchian clastic wedges sedimented in two distinct tectonic depressions, connected by the sedimentary by-pass (Landi et al., 2002-2003) of the “Mt. Perpoli high”, active since the beginning of the Villafranchian deposition, the lithofacies associations characterizing AFB as well as PLB are quite similar in both areas. Furthermore, the boundary between AFB and PLB shows the same features in both depressions, even if the field evidence is not helpful to choose between the existence of a disconformity or a stratigraphic transition between AFB and PLB.

- Although the correlation between continental clastic successions, not supported by sedimentological analysis and paleontological data is difficult, in our opinion the AFB and PLB can be correlated with the “Argille, sabbie e conglomerati di Aulla” and the “Conglomerati di Olivola”, respectively (Puccinelli et al., in press, b). Both crop out north-westward in the Magra Valley (Aulla-Olivoila and Pontremoli tectonic depressions) and show strong affinities with AFB and PLB. The “Argille, sabbie e conglomerati di Aulla” consists of fine grained lithofacies characterized by a variable amount of centimetric to decimetric lignite fragments and organic-rich horizons, with medium to thick coarse grained sandy conglomeratic interbeddings. The overlying “Conglomerati di Olivola” is represented by coarse grained conglomerate and subordinate fine grained interbeddings.

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