

## OLIGOCENE FAN-DELTA DEPOSITS IN NORTHERN ITALY: A SUMMARY

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*Riassunto.* Lungo le colline e le basse montagne al limite tra Piemonte e Liguria affiora un'unità oligocenica, prevalentemente conglomeratica, nota come Formazione di Molare o come Conglomerati di Savignone. Questa formazione si estende per più di 100 km, con direzione ENE-OSO, dai dintorni di Genova fin quasi a Cuneo. I conglomerati che la costituiscono rappresentano, per la maggior parte, conoidi alluvionali oligoceniche depositi al limite tra la terraferma ed un bacino marino (« fan-deltas »). Lo studio sedimentologico ha consentito l'individuazione di diciotto principali litofacies e la loro interpretazione. Per alcune delle più estese conoidi sono state riconosciute associazioni di litofacies indicative della zona prossimale, della zona intermedia, della zona distale (suddivisa in due sottozone: aree di foce + parte superiore del pendio frontale del delta; aree comprese tra le foci) e della zona di prodelta.

A mainly conglomeratic formation, Oligocene in age, crops out in northern Italy at the boundary between Piemonte and Liguria. This unit is forming a more than 100 km elongated belt, roughly NE-SW oriented, and is known in literature as « Formazione di Molare » or « Conglomerati di Savignone » (the latter in the north-eastern part of the outcrop area). The conglomerates represent the first Cenozoic deposits resting unconformably on a basement constituted of pre-Cenozoic sedimentary and metamorphic rocks (Sacco, 1889-1890; Rovereto, 1939; Franceschetti, 1967; Lorenz, 1969; Ibbeken, 1970; Bellinzona & Boni, 1971; Servizio Geologico d'Italia, 1969 a, b, 1970 a, b, 1971).

Most of these conglomerates have been interpreted as representing Oligocene alluvial fans, deposited partly in the sea (Gnaccolini, 1978 a, b, 1980, 1981; Gelati & Gnaccolini, 1978). In the present paper the main sedimentological characteristics of these fan-deltas will be summarized.

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### Main fans or groups of fans.

The thickest fan deposits outcrop at the eastern edge of the conglomeratic belt, between Ovada and the valley of the Borbera creek, some 35 km NNE of Genoa. Well developed fan sequences are present also near Rossiglione, Piana Crixia, Bagnasco, etc., towards the SW.

Based on their petrographic composition, five main fans or groups of fans have been identified (Fig. 1): A) Val Borbera-Val Vobbia fans, B) Cipollina-M. Reale fan, C) M. Alpe fan, D) M. Lanzzone-Sottovalle fans and E) Bagnasco fan.

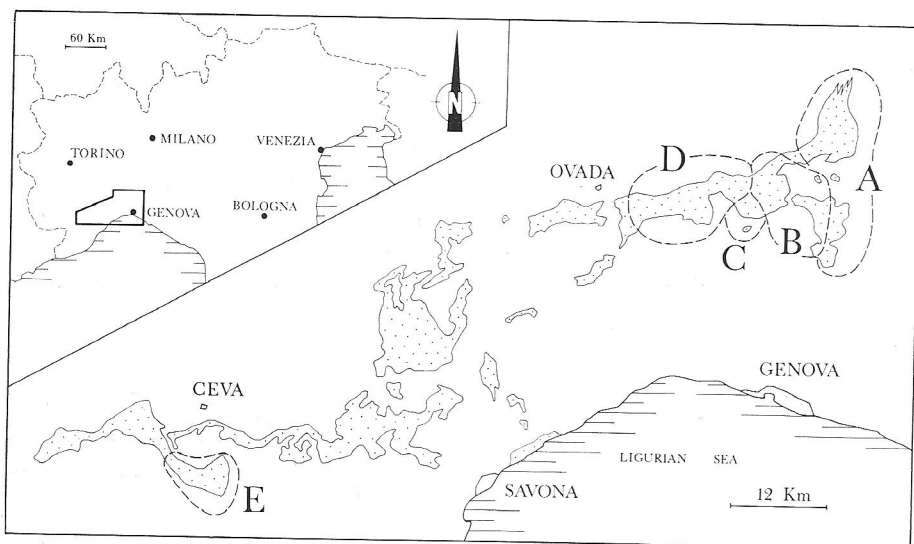


Fig. 1 - Outcrop area of the mainly conglomeratic formation known as «Formazione di Molare» or «Conglomerati di Savignone» (Oligocene). A) Val Borbera-Val Vobbia fans; B) Cipollina-M. Reale fan; C) M. Alpe fan; D) M. Lanzzone-Sottovalle fans; E) Bagnasco fan.

The conglomerates of the Val Borbera-Val Vobbia fans are mainly characterized by calcilithite and calcilutite clasts (up to 100%), associated often with small amounts of ophiolites, quartz, etc. Their thickness is up to 2,500 m. The Cipollina-M. Reale fan is constituted of polymictic conglomerates: the main components are calcilithites and calcilutites (from 35% to 70%), and ophiolites (up to more than 50%, and generally represented by spilites). Marls, cherts, dolomites and calcite fragments have been generally observed in a lesser amount, but dolomitic or marly clasts may be locally very abundant. The maximum thickness is about 250 m. The clasts from the M. Alpe fan,

up to 250 m thick, are exclusively ophiolites. The conglomerates of the M. Lanzone-Sottovalle fans show a variable composition: ophiolites, generally serpentinites, are always present (from 20% up to 70% and more), associated with a variable amount of dolomites, limestones and calc-schists; dolomitic clasts may be locally dominant. The maximum thickness is 500-600 m. The clasts from the Bagnasco fan, up to 350-400 m thick, are mainly calcareous dolomites, dolomitic limestones, quartzites, quartz, micaschists, etc.; ophiolites are rare.

#### Main lithofacies: description and interpretation.

Sedimentological studies carried out on the conglomeratic sequences allowed to identify 18 main lithofacies, which are synthetically described following a scheme similar to that used by Miall (1978) for braided river deposits:

FACIES CODE	LITHOFACIES AND SEDIMENTARY STRUCTURES	INTERPRETATION
C 1	inversely graded conglomerates	sediment gravity flows: debris flows <i>sensu</i> Lowe (1979)
C 2	inversely-to-normally graded conglomerates	tentatively attributed to subaerial sediment gravity flows, owing to their stratigraphic relationships with other rock types; these conglomerates have been generally observed in subaqueous environments as deep sea fans (Walker, 1975, 1978) or delta-front slopes (Massari, 1978; Nemeč et al., 1980)
C 3	normally graded conglomerates	subaqueous sediment gravity flows; or stream flow deposits (longitudinal bars, channel deposits)
C 4	massive, matrix supported conglomerates (muddy matrix)	sediment gravity flows (debris flows)
C 5	massive, very poorly sorted, coarse conglomerates (blocks up to few metres can be locally present)	sediment gravity flows: debris flows <i>sensu</i> Lowe (1979)
C 6	massive to crudely bedded conglomerates	stream flow deposits: sheet bars, longitudinal bars, lag deposits; locally, sediment gravity flows (delta-front slope)
C 7	conglomerates with well developed horizontal bedding, locally openwork (Smith, 1974)	stream flow deposits: sheet bars, longitudinal bars, lag deposits

FACIES CODE	LITHOFACIES AND SEDIMENTARY STRUCTURES	INTERPRETATION
C 8	sandy conglomerates, with low-angle cross-bedding or horizontal bedding	stream flow deposits: linguoid bars, deltaic growths, channel fills; longitudinal bars
C 9	layers of cobbles and boulders bored by Bivalves or encrusted by Corals or Oysters	coarse, fluviatile deposits, winnowed by waves, bored or encrusted by marine organisms
C 10	thin conglomeratic beds (disorganized or normally graded) and thin sandy turbidites interlayered with marine mudstones (M 1)	resedimented conglomerates and sandstones (prodelta deposits)
S 1	fossiliferous, pebbly sandstones, with low-angle cross-bedding	delta-front and upper delta-front slope deposits
S 2	cross-laminated to massive sandstones and pebbly sandstones, locally with mud intraclasts	stream flow deposits: dunes, linguoid, transverse bars, scour fills
S 3	massive sandstones, with clusters of marine fossils	beach deposits, backshore to foreshore
S 4	fossiliferous sandstones, with horizontal lamination or low-angle cross-lamination	beach deposits, backshore to upper shoreface
S 5	bioturbated sandstones	beach deposits, lower shoreface
S 6	siltstones, mudstones and fine sandstones, with fine laminations and very small ripples; locally, fresh water organisms, abundant plant remains and coal lenses	lake and swamp deposits
M 1	massive mudstones, with marine fossils	marine deposits, sublittoral environment
M 2	massive mudstones, with no fossils, generally interlayered with S 2, C 7 or C 8	stream flow deposits (overbank, backswamp deposits)

#### Fan-delta zonation and lithofacies associations.

In the mentioned fan-delta complexes four major zones have been identified: 1) Proximal zone, 2) Medial zone, 3) Distal zone (3a, Channels mouth area and upper part of the delta-front slope; 3b, Interdistributaries area), 4) Prodelta zone (Fig. 2).

The first zone is characterized by alternating stream flow and debris flow deposits; the second zone by different types of stream flow deposits; the distal zone by stream flow deposits and by beach to shallow marine sediments; the prodelta zone is represented by marine muddy sediments with some interbedded mass flow deposits.

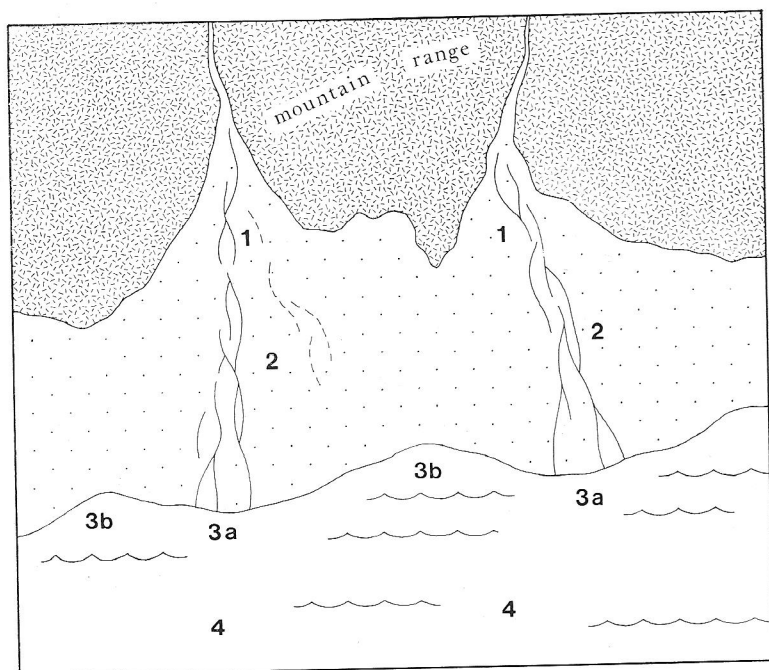


Fig. 2 - The proposed fan-delta zonation which can be applied in the studied area during the Oligocene: 1) Proximal zone, 2) Medial zone, 3) Distal zone (3 a, Channels mouth area and upper part of the delta-front slope; 3 b, Inter-distributaries area), 4) Prodeltal zone.

The most complete facies association has been recognized in the *M. Lanzone-Sottovalle fans* (Fig. 4). The proximal zone is represented by lithofacies C 6 and C 1; the medial zone by lithofacies C 6 interbedded with C 3, C 8, S 2; the distal zone 3a by C 6, C 8, S 1 (seldom C 4) rhythmically interlayered with M 1; the distal zone 3b is represented by C 9, S 3, S 4, S 5 and M 1; the prodelta zone is characterized by M 1 or by M 1 and C 10.

The distal zone 3a has not been observed in the *Cipollina-M. Reale fan*, but the other parts of the fan are well developed (Fig. 3). The proximal zone shows the facies association C 6, C 2, C 1, locally C 7; the medial zone is testified mainly by C 6 and C 7, locally with C 8; the distal zone 3b by S 3, S 4, S 5 and M 1; lithofacies M 1 characterizes the prodelta zone.

Only the proximal zone has been identified in the *M. Alpe* conglomerates; this zone is represented by lithofacies C 5 and C 6, with rare lenses of S 2.

The *Val Borbera-Val Vobbia fans* (Fig. 3) show a well developed medial zone, represented mainly by C 6 and C 7, locally interbedded with S 2 and M 2; C 3 and C 5 have been seldom observed. The distal zone 3b shows the association C 9, S 3, S 4 and S 5, while the prodelta zone is characterized by M 1, with more or less developed intercalations of C 6 (often with muddy matrix) and C 4 (rare).

All the above mentioned fans were deposited partly under marine conditions. The *Bagnasco fan*, on the contrary, was deposited partly in a shallow lake. His proximal zone is testified by lithofacies C 5 and subordinately C 6; the medial zone is represented by C 6 and S 2, rhythmically interbedded and with very frequent erosional scours; the distal zone by S 6 and S 2, with some intercalations of C 1, C 6 and C 3; lithofacies S 6 testifies the lacustrine prodelta zone (Fig. 4).

#### Conclusions.

Based on those lithofacies associations, a zonation for the Oligocene fan-delta complexes identified in NW Italy may be proposed. The fan-deltas developed in areas with extremely steep gradients and high energy environments, resulting in very coarse sediments.

The proximal zone is characterized by the association of two or more of the following lithofacies: massive to crudely bedded conglomerates; inversely graded conglomerates; inversely-to-normally graded conglomerates; massive, very poorly sorted, coarse conglomerates; conglomerates with well developed horizontal bedding, locally openwork.

The medial zone is testified by the following lithofacies association: massive to crudely bedded conglomerates; conglomerates with well developed horizontal bedding, locally openwork; sandy conglomerates, with low-angle cross-bedding or horizontal bedding; normally graded conglomerates; cross-laminated to massive sandstones and pebbly sandstones, locally with mud intraclasts; massive, unfossiliferous mudstones may be locally interlayered.

The interdistributaries distal zone is represented by massive, fossiliferous sandstones, by fossiliferous sandstones with horizontal lamination or low-angle cross-lamination and by bioturbated sandstones; massive mudstones with marine fossils may be locally present.

The channels mouth area and the upper part of the delta-front slope are generally characterized by the following lithofacies association: sandy conglomerates, with low-angle cross-bedding; fossiliferous, pebbly sandstones, with low-angle cross-bedding; massive to crudely bedded conglomerates; massive mudstones, with marine fossils (these mudstones

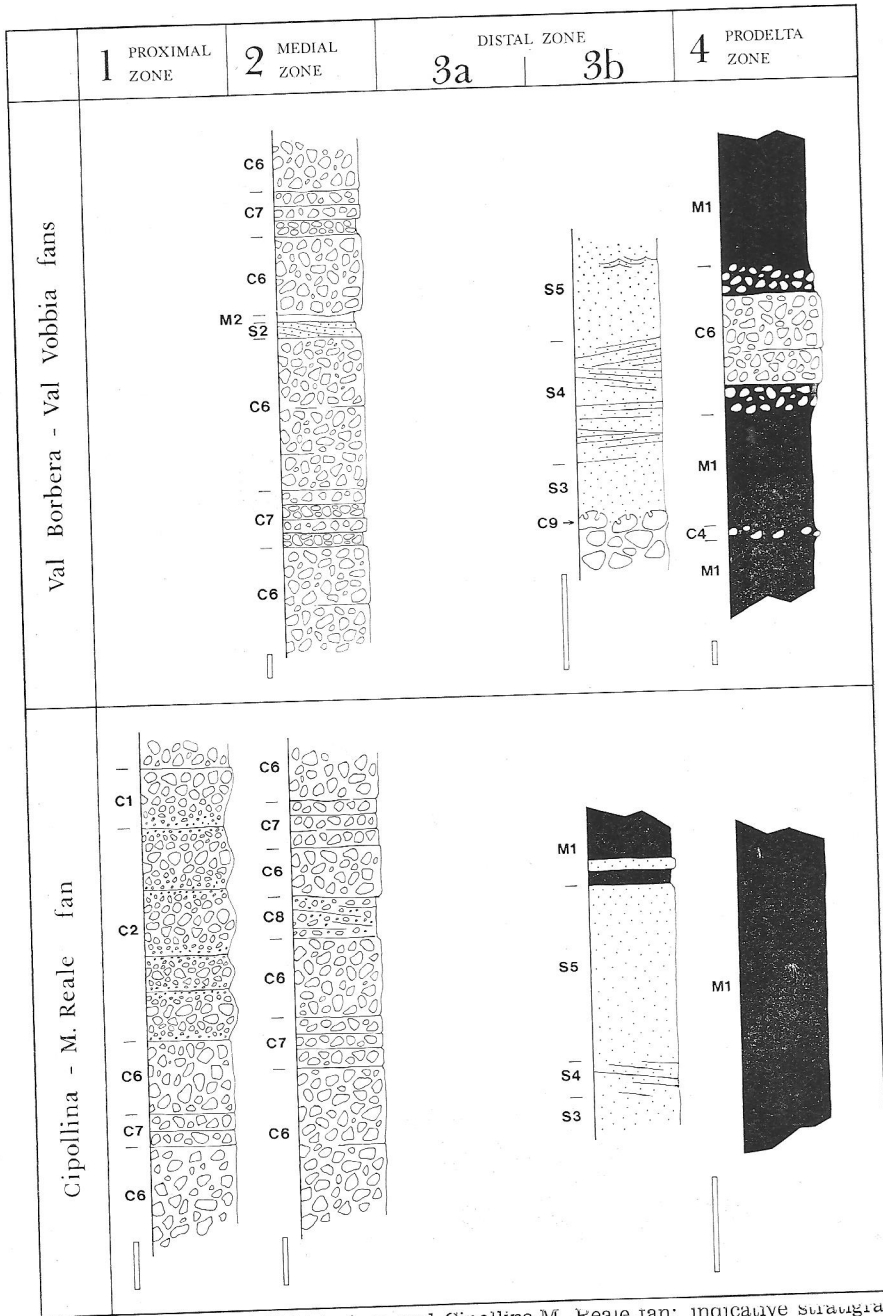


Fig. 3 - Val Borbera-Val Vobbia fans and Cipollina-M. Reale fan: indicative stratigraphic sections. Scale bar = 1 m.

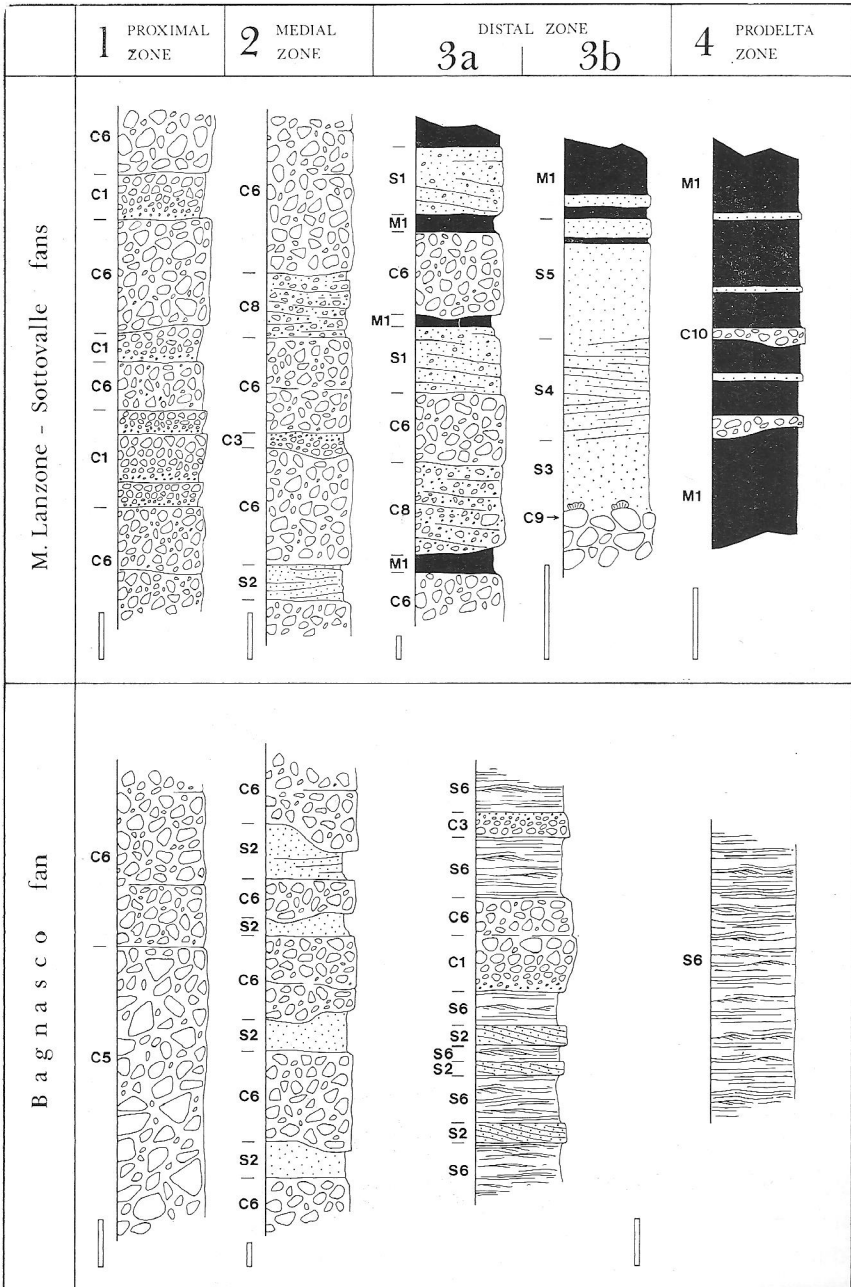


Fig. 4 - M. Lanzone-Sottovalle fans and Bagnasco fan; indicative stratigraphic sections. Scale bar = 1 m.



are rhythmically interlayered with the above mentioned deposits).

The prodelta zone is represented by marine fossiliferous mudstones, with some resedimented conglomeratic layers (thin conglomeratic beds, disorganized or normally graded; massive to crudely bedded conglomerates).

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