Sedimentology and Depositional Setting of the Miocene Marnoso-Arenacea Flysch, Central Apennines, Marches Region, Italy

Colleen Dunlevy
Department of Geology, Washington and Lee University, Lexington, VA 24450
Faculty Sponsor: Fred Schwab, Washington and Lee University

INTRODUCTION

A sequence of conglomerate, marl, sandstone, and mudstone was studied in a small valley in the Italian Apennines about 50 km Southwest of Ancona. (Fig. 1) This area has undergone two distinct periods of tectonic activity. The first was a period of extension. This produced elevated seamounts (or horsts), and basins that were filled in by carbonate sediment during the Cretaceous and Tertiary. (Bice, 1990) By the late Tertiary the sea floor was topographically even when a period of compressive tectonic activity generated thrust faulting across the Italian peninsula. Compression began in the southwest and moved toward the northwest in a wave across Italy reaching the area of study in the early Miocene.

The Marnoso-Arenacea flysch, a portion of which is the subject of this study, was deposited during this compressional period. It locally overlies the Bisciaro formation, a deep marine sequence of limestone, marl, and ash of Miocene age that were deposited just before, or during the early stages of tectonic activity. A sequence of bedded evaporites that overlies the Marnoso-Arenacea flysch indicates that water depth has greatly decreased since the deposition of the Bisciaro.

The study was conducted in a small basin located west of the Cingoli anticline. The Marnoso-Arenacea in this area consists of thick-bedded coarse sandstone, coarse and fine conglomerates, marls and thin bedded fine sands and muds. The purpose of this study is to determine the provenance of the sandstones, to reconstruct a depositional environment, and to determine if the rise of the Cingoli anticline influenced deposition in the basin.

METHODS

Four sites with good outcrop exposure were selected. Detailed stratigraphic measurement emphasized composition, texture, and sedimentary structures allows four distinct facies to be characterized.

Eleven thin sections were point-counted for composition and texture to infer provenance and transporting agents. Textural attributes for conglomerates at the top of the Coldigioco North section were analyzed directly on the outcrop. This detailed petrographic data supports the four facies defined in the field.

FACIES DESCRIPTIONS

Four distinct facies occur in the basin.. Each facies consists of a series of beds of distinct composition. Figure 2 graphically represents each measured section. Numbers found in the text correspond to those in the figure.

Facies A. This facies consists of a coarsening-upward series of clastic sedimentary rock exposed in the Coldigioco North section. The base of this sequence (I) is a medium to fine sandstone showing synsedimentary contortions and postdepositional shear zones. (A change in strike and dip within the middle of the unit indicates local strain.) The beds overlying the medium sandstone coarsen upward; interbedded marls occur at intervals.

Most of the sandstones in this facies are structureless or show parallel lamination. However, two graded beds occur at meter 25.5 of the Coldigioco North section (II). These two beds are each about .75 m thick and show normal grading. The bottom of the lower bed shows a planar contact with the coarse sand below it, and the top bed shows an irregular contact with the lowermost graded bed. The base of each bed is a pebble/ granule conglomerate containing pebbles and granules of white limestone, green and red chert, and quartz in a matrix of very coarse sandstone with abundant muscovite. This coarse material grades into a tan coarse sandstone with granules of similar composition to those in the base. The sequence repeats itself in the second bed and is overlain by a twelve centimeter thick very fine sandstone that shows ripple cross lamination. This sequence is found only once in the Coldigioco North section. Poor exposure and extensive weathering of sections of the outcrop could mask other graded beds.

Facies B. This is a second coarsening upward sequence distinguished from facies A by lenticular bedding and very coarse conglomerates. This facies occurs in the upper part of the Coldigioco North section.

The first lenticular bed occurs just below the coarse conglomerates at Coldigioco North. (III) The conglomerate surrounding the lenticular bed is a medium to coarse, poorly cemented, and poorly sorted conglomerate that contains about 5% white limestone granules and sand size clasts of chert and flakes of mica. Concretions up to one meter long and twenty centimeters thick that occur within the unit suggest channel outlines.

The lenticular bed in the outcrop is thirty centimeters thick at its thickest point. The margin is poorly defined, and the bed consists of two units. A ten centimeter thick pebble conglomerate contains a matrix of coarse sand with spherical to flattened limestone pebbles that measure 3.5 cm along the long axis forms the bottom of the bed. A very few siltstone intraclasts up to eight centimeters long are also present. The second unit of the lenticular bed is a pebble conglomerate twenty centimeters at the thickest point, also with a matrix of very coarse sandstone. Clasts of siltstone, limestone, and mudstone (up to 35 x 4 cm) occur. Above the lenticular bed, the conglomerate coarsens near the top.

The lowermost coarse conglomerate (IV) occurs just above a covered area in the section. The base of the bed is not visible. One to 1.15 meters of measurable section reveal a clast-to matrix-supported boulder conglomerate with no grading. This conglomerate contains white and grey limestone and marl clasts of the Miocene Bisciaro formation measuring up to 1 x 1.3 m in size in a matrix of coarse sandstone and mudstone. The boulders are subangular to well rounded with roundness generally increasing with increased clast size. The larger boulders are almost entirely limestone or marl, but some smaller boulders and cobbles are siltstone, mudstone, and coarse and fine sandstones. There is an irregular contact between this bed and the overlying bed where some of the larger boulders protrude from the top of the bed. Two cobble conglomerates (V) showing weak inverse grading overlie the boulder conglomerate and lie beneath a pebble conglomerate that is deeply cut by a lenticular bedded cobble conglomerate above it. The pebble conglomerate contains scattered cobbles in the first half a meter at the base. The cobble conglomerates are formed almost entirely of white limestone clasts (similar to the limestones of the Bisciaro formation) in a matrix of coarse sand.

Facies C. This fining upward series can be seen in the Turkey pen and Fornaci sections. It fines upward from a poorly sorted pebble- granule conglomerate to a moderately well-sorted medium sandstone. The bottom of the section at Fornaci shows this facies. The bottom 1.8 meters of measurable section at Fornaci is a pebble conglomerate with pebble size clasts of mudstone near the base and limestone and chert throughout. (VI) The granules and pebbles show cross lamination. This bed grades into a sixty centimeter very coarse sandstone conglomerate containing granule-rich layers approximately one centimeter thick throughout. The granule-rich unit grades into a coarse sand conglomerate twenty to one hundred seventy cm thick that is cut by a large lenticular bedded granule conglomerate that fines into a very poorly sorted, very coarse sand conglomerate. (VII) The top of the lenticular bed is defined by a half meter of poorly sorted medium sandstone with approximately 10% coarser material. The bed ranges in thickness from 1.2 to 1.5 meters. Above the lenticular bed, the coarser material becomes concentrated into granule rich horizontal laminae that alternate with granule poor coarse to medium sandstone. Except for concretions that generally parallel the bedding, the rest of the sequence is structureless and fines gradually over twenty-four meters. The same sequence (excluding the lenticular bed) can be found in the Turkey Pen section.

Facies D. This facies consists of interbedded ripple cross-laminated or parallel-laminated very fine sandstones and siltstones and parallel-laminated or structureless mudstones. These lithologies can be seen in the upper portion of the Fornaci section. The beds occur in sequences of two or three bed showing C-E Bouma sequences. At the bottom of most of the sequences is a ripple cross-laminated fine sandstone or siltstone. This is overlain by a parallel-laminated mudstone and structureless mudstone, though the parallel-laminated mudstone is not always present. Poor exposure characterizes this section, but in one area a full Bouma sequence missing only the A bed was found. (VIII).

TRANSPORT AGENTS AND DEPOSITIONAL SETTING

Textural analysis and field observation indicate that the facies in this basin were part of a submarine fan complex. Each facies represents a different part of the fan.

Facies A. The thick sandstone beds and coarsening-upward sequence typify upper fan channel fill deposits. Thick sandstones, commonly slumped, are the main channel deposits. Convolutions at the base of the sequence may be the result of minor slumping. The graded beds are grain flows that occur in the main channel.

Facies B. The conglomerates of this facies were deposited in the upper section of a submarine fan, perhaps in the feeder channel to the fan. The conglomerates are debris flows. Clasts have not been transported far, based on the degree of rounding seen in the large boulders and cobbles. Lenticular beds are channel deposits. Concretions in the fine conglomerate below the debris flows may trace the bottom of migrating channels. They cut the conglomerate into lenticular sections that migrate from side to side, and could be the result of a migrating channel at the head of the fan. The debris flows are the result of deposition in the large feeder channels for the fan. Thin section analysis further strengthens the case that these are upper fan deposits. These deposits are poorly sorted and very angular, as would be expected in the portion of the fan closest to the source.

Facies C. The conglomerates and sandstones of this facies resemble channel deposits from the mid-fan suprafan lobe channels. Walker (1979) describes channelized pebbly sandstones in braided suprafan channels. As the channel fills with successive deposits, the sediments fine upward. Mid-fan channel pebbly sandstone deposits can be graded, channeled, and show horizontal lamination or various forms of cross-stratification. Thin sections show an increase in sorting and rounding as the unit fines upward. This trend demonstrates the filling of the channel. As the channel fills, the sediments become better sorted and rounder due to a decrease in slope.

Facies D. These deposits represent the distal portion of the fan, where slower moving turbidite currents deposited fine sands and muds in C-E Bouma sequences. Large numbers of these C-E Bouma sequences indicate that this facies was deposited distally. However, there is an alternative explanation for these fine sands and muds. Inner fan levees also consist of mud and silt. Where currents are strong enough, rippling of the silt produces C-E turbidites much like the ones produced in the distal portion of the fan. Since this deposit is found above a channelized mid-fan sandstone, the silts and muds could be levee deposits, but the abundance of fine sand in these beds suggests a more distal environment, because levee deposits usually only contain the finest particles. (Walker, 1979)

The abundance of carbonate clasts examined the sandstones and debris flows suggests that the sediments were locally derived, but lack of directional structure indicators precludes inferences on flow direction. Changes in dip, shear planes, and contortions in the sediments suggest that the growing anticline affected deposition. Changes in thickness of beds due to tilting during deposition probably occur, but poor exposure does not allow lateral changes in thickness to be detected. The growth of the anticline may have influenced deposition, but there is little evidence to support such a conclusion.

PROVENANCE

Compositional analysis of thin sections indicates that the sandstones in this study were deposited adjacent to an area of high relief. Abundant carbonate clasts (up to 43% in one sample) indicate that the source area was relatively high. These carbonates would have been dissolved in an area of low relief. Mean roundness of clasts ranges from angular to subrounded, together with large boulder size, suggesting that the source area was very close.

CONCLUSION

The sequence of Marnoso-Arenacea flysch found in a small basin west of the Cingoli anticline represents a submarine fan deposit. The sedimentary sequence indicates that submarine fans supplied sediments eroded from a topographicly high carbonate rich souce into the synclinal basin. Field observation and thin section analysis indicate four distinct facies corresponding with four different areas of the fan.

REFERENCES CITED

Bice, D. M. and Stewart, K. G., 1990, The formation and drowning of isolated carbonate seamounts: tectonic and ecological controls in the northern Apennines: Carbonate Platforms: facies, sequences, and evolution, p.145-168

Walker, R. G., 1979, Turbidites and Associated Coarse Clastic Deposits: Facies Models, p. 91-104

Figure 1. Map of the field area.

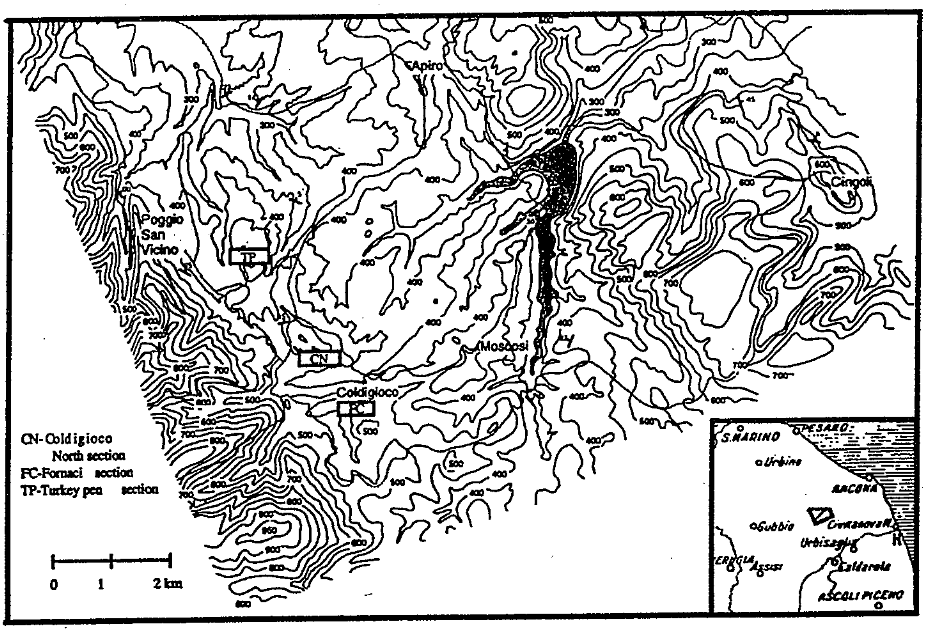

Table 1: Summary of facies analysis

	Facies A	Facies B	Facies C	Facies D
Facies description	Coarsening upward sequence of medium sands to very coarse sand	Coarsening upward sequence of pebble conglomerates to boulder conglomerates	Fining upward sequence of pebble conglomerates to medium sands	Fining upward sequence of thin bedded fine sands and muds
Sedimentary structures	some graded beds, parallel lamination, few ripple cross laminated sands	lenticular bedding, weak inverse grading in some conglomerates	lenticular bedding, parallel lamination, graded bedding	ripple cross lamination, parallel lamination, convolute lamination.
Tectonic structures	convolute bedding, shear planes, change in strike and dip of beds		change in dip of beds, shear planes	
Sorting	moderately well sorted	poorly sorted	poorly at bottom to moderately well at top	moderately well to well sorted
Typical grain size	medium sands	cobble/boulder	granule at base to medium sand at top	very fine sand to mud

Figure 2. Stratigraphic columns of measured sections.