Geology of the Coldigioco-Castellaro Basin in the northern Apennines fold and thrust belt, Italy

brandon gillis
Department of Geology, Whitman College, Walla Walla, WA 99362
faculty Sponsor: Kevin R. Pogue, Whitman College

INTRODUCTION

The 1995 Keck Geology Consortium summer research project in the northern Apennines of east-central Italy was based at the Osservatorio Geologico di Coldigioco (OGC). Located in the hills of the Apennine fold and thrust belt (see figure 1), it is ideally situated for studying geology. Previous geologic field work in the area includes study of exhumed Jurassic carbonate seamounts (Bice and Stewart, 1990), the K-T boundary (Alvarez, et al., 1980), foreland basins (Ricci-Lucchi, 1986), and numerous other projects. The 1995 Keck project focused on the tectonics and sedimentology of the region. The location of the OGC provided an ideal opportunity to study the sedimentation and structure of the foreland basin environment. The specific goal of the study described herein is to better understand the timing of the growth of the basin-bounding anticlines by mapping and studying the sedimentary rocks of the basin.

GEOLOGIC SETTING

The northern Apennines thrust belt is a result of complex and incompletely understood Mediterranean microplate dynamics. Previous work has provided a good background of the geologic history of the area. The oldest exposed rocks are Jurassic carbonates which crop out at high elevations in the cores of anticlines. The broad regionally extensive carbonate platform on which they were deposited foundered in the Jurassic and was replaced by pelagic sedimentation which remained dominant until Early Miocene time (Calamita, et al., 1994). Miocene to Pliocene pelagic to terrigenous sediments are exposed primarily in the basins of the area. Tectonically, the Apennines are an east-northeast vergent fold and thrust belt. The structures are a result of northeast-southwest compression and shortening of the African-Adriatic continental margin which began in the Late Oligocene and continued to migrate toward the northeast until present (Calamita, et al., 1994; Ricci-Lucchi, 1986). Hinterland extension began at approximately the same time and has followed the eastward migration of the compressional fronts (Lavecchia and Brozzetti, 1994). The current model for this thrust belt is deep seated west-dipping thrusting of multiple slabs of basement which has resulted in crustal thickening to the east (Apennines) and thinning to the west (Tyrrhenian) all accompanied by a counterclockwise rotation of 60° to 90° from east to northeast (Oldow, et al., 1993; Ghisetti and Vezzani, 1991). Foreland directed tectonic activity has produced a series of piggy-back basins that are carried on active thrust sheets which develop in the footwalls of older thrusts. These basin rocks record the migration of depocenters which in turn reflect the deep rooted thrust activity (Zoetemeijer, et al., 1992). Post-orogenic extensional faulting following the compression has reactivated many older structures and created intramontane basins (Calamita, et al., 1994). The Coldigioco-Castellaro foreland basin provides an example of a piggy-back basin to study.

METHODS

The OGC is located within the basin of study. This proximity facilitated detailed exploration of the surrounding area in search of outcrops. Transportation was primarily by motorcycle which allowed access to many otherwise inaccessible outcrops. Approximately 50 outcrops within the basin were examined. At each outcrop geologic data including lithologic descriptions, orientation of bedding, and paleocurrent indicators was obtained. Three stratigraphic sections were measured to further describe units and potential mechanisms of deposition.

Figure 1: Map of Italy, showing field area (X).

UNIT DESCRIPTIONS

The field area shown in Figure 2 is dominated by two northwest-southeast trending anticlines composed of uplifted Jurassic to Early Miocene limestone which bound the interior synclinal basin. The basin is filled with Miocene to Pliocene sandstones, marls, and other marine sediments. The Messinian stage of the Late Miocene is marked in the surrounding area by gypsum-rich evaporites from a Mediterranean salinity crisis, though is suspiciously absent from the area of study. Hence, the Miocene may be further subdivided into pre or post-evaporitic (Odin, et al., 1995). Much of the area is covered by Pleistocene gravels, Quaternary alluvium, and is thickly vegetated.

The oldest unit in the research area is exposed along the flanks of the bounding anticlines. These exposures consist of white to pink pelagic limestone of Paleocene to Miocene age. This unit is commonly exposed in hillside roadcuts. The outcrops are primarily comprised of the Biscaro, Scaglia Cinerea, and Scaglia Variegata Formations which for this study have been lumped into the unit "Paleocene to Miocene limestone."

At the southern extent of the research area, a weathered tan sandstone unit was mapped. This unit ranged from weakly to well-cemented and was predominantly massive with occasional concretion-rich layers. This sandstone is of middle Miocene age and is pre-evaporitic (Odin, et al., 1995).

A unit of clay-rich marls with occasional fine sand interbeds was mapped. This unit has been named the Colombacci Formation, and is the regional marker for the uppermost Messinian. It contains a biotite-rich tuff which yielded an age of approximately 5.5 Ma (Odin, et al., 1995). Odin, et al., (1995) have suggested that the Colombacci Formation be further subdivided into the Tetto Formation (clay-rich marls) and Formation with Colombacci (clay-rich marls with thin limestone layers) on the basis of their study of the Maccarone section (see Fig. 2), and those of basins to the south. For the purpose of this study the Late Miocene (Messinian) clay-rich marls have been combined into one unit.

Pliocene rocks in the region were previously mapped as one unit by the Italian Geologic Survey. Detailed mapping of the basin allows the subdivision of the Pliocene into two units. The older unit consists primarily of interbedded gray marls and fine-to medium-grained sandstones that represent the transgressive sequence which occurs just above the Miocene-Pliocene boundary (Odin, et al., 1995). This unit is spectacularly exposed in the cliff south of Castellaro. Above the transgressive unit is a resistant yellow/tan sandstone. This caprock-forming unit forms the plateau on which Castellaro lies. The unit also comprises the caprock on which Cupramontana is situated, as well as several ridges in the area . In some areas, such as La Aqua, the resistant sandstone unit lies unconformably over Miocene marls. The youngest unit mapped consists of Pleistocene gravels and Quaternary alluvium which have been grouped together for this study.

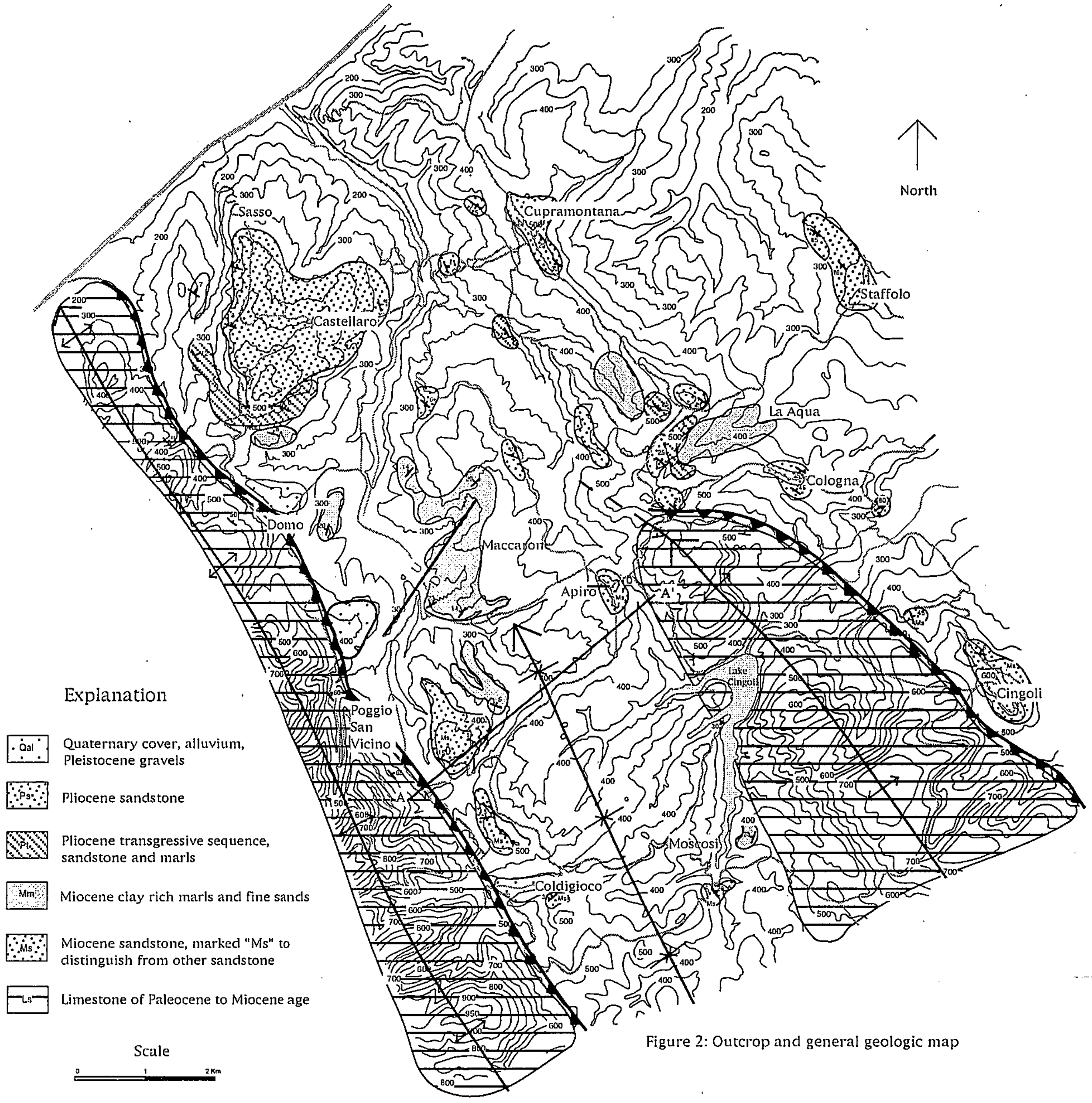
OBSERVATIONS AND INTERPRETATIONS

The rocks within the basin generally young to the north due to the northwest plunge of the regional structures. Paleocurrent indicators show an approximate south/southeast direction of deposition into the basin. Many of the basin rocks are easily erodable, of which the badlands-forming marls of Messinian age provide the best example.

The trend of the bounding anticlines is primarily northwest-southeast. The southern extent of the basin forms a syncline also trending northwest-southeast, as is indicated by a diagramatic cross-section of the basin (Figure 3).

Generally, the dip of the rocks is steeper in the southern part of the basin. This relationship corresponds with the southwest to northeast direction of thrusting (Calamita, et al., 1994), as the older rocks within the southern part of the basin have been more extensively deformed. Perhaps this deformation is a result of the bounding thrust extending into the basin sediments in the southern part of the basin. The basin sedimentary rocks have a similar attitude to the flanks of the bounding anticlines, and the older rocks at the edges of the syncline have steeper dips than the younger rocks in the core because they have experienced a longer period of deformation. These relationships indicate that the anticlines experienced growth during and since the Late Miocene-Pliocene.

The oldest sandstones of the basin, exposed to the north and south of Coldigioco, and just south of Moscosi are locally folded and have steep dips. Debris flows, interpreted to have resulted from the over-steepening of slopes on the flanks of the growing anticlines, are present within the vicinity of these exposed folds. Younger rocks in the basin are not folded. The folds and associated debris flows within the southeastern rocks of the basin suggest that the anticline to the east experienced events of rapid growth and thrusting during the Miocene. The dips of the Pliocene sandstone shallow in the northern part of the basin, perhaps in response to the slowing or cessation of growth of the anticlines, or as a result of being carried piggy-back without further deformation.



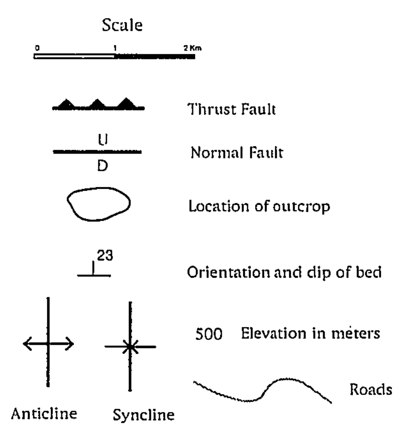


Figure 2: Outcrop and general geologic map

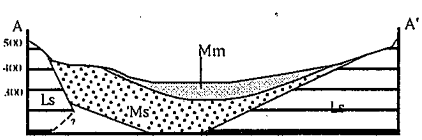


Figure 3: Generalized diagrammatic cross-section of basin

A northeast-trending normal fault was observed cutting the Messinian marls. This fault offsets the biotite-rich tuff of the Colombacci Formation. Normal faulting in this area is presumed to be a result of extensional tectonics which followed compression.

During the Miocene and Pliocene, the basin remained submerged as the two bounding anticlines, which were seamounts at this time, were emerging. Deposition was from a northern source, as indicated by paleocurrent measurements. The current Bosnian coastline (Dalmation coast), which consists of a series of elongate northwest-trending seamount islands, provides a modern analog. Perhaps studying the sedimentation of this area would provide insight into the depositional environment of the foreland basins of the Apennines.

PROBLEMS

The field area has rugged topography and though the area is inhabited and farmed, extensive vegetation caused difficulty in reaching outcrops. Many of the best outcrops are virtually inaccessible due to rivers, dense vegetation, and steep and often muddy slopes. In these conditions, even well-exposed outcrops may be out of reach. Pleistocene gravel, predominantly flanking the anticlines, obscures many contacts, as well as possible faults.

Perhaps the biggest unsolved question concerns the provenance of the sandstones. Of the dominant lithologies mapped in the basin, the sandstone has no local source. The Alps have been identified as a possible source area (Stewart, 1987; Ricci-Lucchi, 1986), but no suitable method of transport has been determined. Perhaps reworking of older turbidites shed from the growing anticlines would best fit this situation (Ricci Lucci, 1986; Bice, personal communication, 1996).

CONCLUSIONS

The Coldigioco-Castellaro basin contains a sequence of sedimentary rocks reflecting the evolution of the area from Late Miocene to Pliocene time. Structural relationships indicate that both of the bounding anticlines were actively growing during deposition of these rocks, and perhaps after. The shallowing dips of younger rocks in the northern portion of the basin indicate that the western anticline experienced a quiescence or slowing of growth during the Pliocene, or perhaps more likely that they were carried piggyback without becoming deformed as the anticlines continued to grow.

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REFERENCES CITED

Calamita, F. Cello, G., Deiana, G., and Paltrinieri, W, 1994, Structural styles, chronology rates of deformation, and time-space relationships in the Umbria-Marche thrust system (central Apennines, Italy): Tectonics, v. 13, no. 4, p. 873-881.

Ghisetti, F. and Vezzani, L., 1991, Thrust Belt Development in the Central Apennines (Italy): Northward Polarity of Thrusting and Out of Sequence Deformations in the Gran Sasso Chain: Tectonics, v. 10, no. 5, p. 904-919.

Lavecchia, G., Brozzetti, F., Barchi, M., Menichetti, M.., and Keller, J., 1994, Seismotectonic zoning in east-central Italy deduced from an analysis of the Neogene to present deformations and related stress fields: GSA Bulletin, v. 106, p. 1107-1120.

Odin, G.S., Ricci-Lucchi, F., Tateo, F., Cosca, M., and Hunzike, J.C., 1995, Integrated Stratigraphy of the Maccaronė Section, Late Messinian (Marche Region, Italy): In Review, 13p.

Oldow, J., D'Argenio, B., Ferranti, L., Pappone, G., Marsella, El, and Sacchi, M., 1993, Large-scale longitudinal extension in the northern Apennines contractional belt, Italy: Geology, v. 21, p. 1123-1126.

Ricci-Lucchi, F., 1986, The Oligocene to Recent foreland basins of the northern Apennines, *in* Allen, P. A., and Homewood, P eds., Foreland Basins: Oxford, Blackwell Scientific Publications, p. 105-139.

Stewart, K., 1987, Anomolous clasts in a Pliocene conglomerate near Pescaro have an Alpine Source *in* Doctoral Thesis, U.C. Berkley.

Zoetemeijer, R., Sassi, W., Roure, F., and Cloetingh, S., 1992, Stratigraphic and kinematic modeling of thrust evolution, northern Apennines, Italy: Geology, v. 20, p. 1035-1038.