Detailed facies mapping of Jurassic carbonates in the area around Monte Pietroso and Monte Scocione in the Apennine mountains of Italy

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INTRODUCTION

The Umbria-Marches Apennine Mountains form a northwest-trending segment of an arcuate thrust belt that extends southward and westward through Calabria and into Sicily. Thrusting occurred in response to the westward subduction of the European plate beneath Adria (Italy) as the African plate moved northward relative to the European plate. Thrusting began in Late Oligocene to Early Miocene time, and is still active in the northern part of the Apennines today. The belt began undergoing extension shortly after it started to form. Extensional and compressional fronts have both migrated to the northeast over time; the active thrust front is now along the Adriatic coastline, and the active extensional front runs through the center of the peninsula (Bice and Stewart, 1990).

The purpose of the project was to create a detailed facies map of the area around Mount Pietroso and Monte Scocione, and to constrain the geometry and timing of Jurassic extensional tectonics in this area. Oligocene-Quaternary compressional and extensional tectonism may have reactivated Mesozoic structures in the Umbria-Marches region. A detailed study of the Monte Pietroso - Monte Scocione area may lead to a better understanding of the influence of older extensional structures on the younger compressional activity.

OVERVIEW OF GEOLOGIC HISTORY

During the Early Jurassic, a large carbonate platform - the Calcare Massicio - developed on Italian continental crust. By the middle of the early Jurassic, the Liguride Ocean basin began to open as the Italian Peninsula moved away from southeastern Europe. The opening of this small ocean basin produced a passive continental margin in the area that is now the northern Apennine Mountains. This margin underwent thinning and subsidence and persisted until the Oligocene when it was reactivated as part of the fold-and-thrust belt (Alvarez and Montanari, 1988).

The Calcare Massicio platform experienced normal faulting during this episode of extension and was fragmented into small isolated seamounts separated by intervening basins. This topography persisted until the beginning of the Cretaceous, when it was drowned as eustatic sea level rose by as much as 2000 meters (Bice, personal communication, 1996). Paleomagnetic data suggests that the study area was 15-30° N latitude at the time of drowning, and separated from any source of significant siliclastic input (Channel et al., 1984, and Westphal et al., 1986, cited in Bice and Stewart, 1990). The setting was therefore favorable for the production of carbonates. The overlying sediments of both the basins and the seamounts are predominantly limestone. Figure 1 is a schematic cross section of a portion of the Northern Apennines that experienced block faulting and drowning.

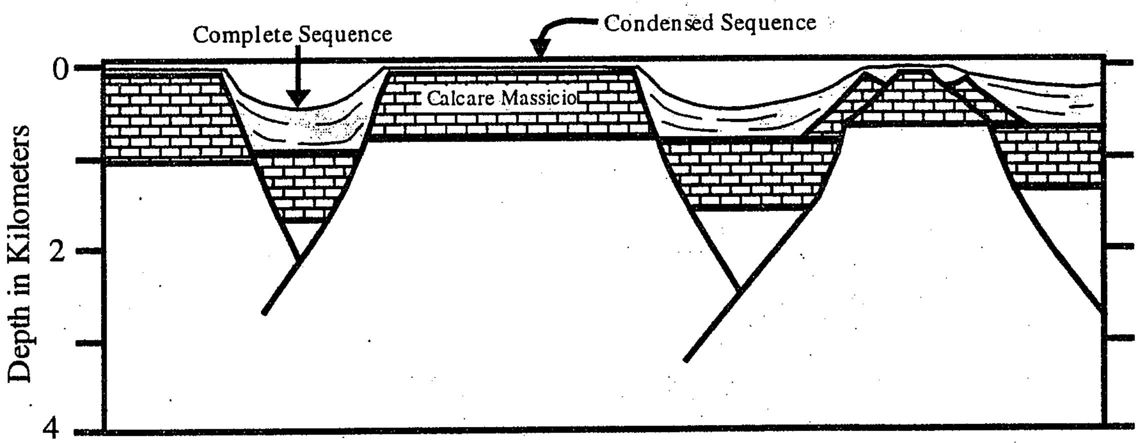

Figure 1. Schematic cross section of a portion of the northern Apennines that underwent block-faulting and drowning in Jurassic time. (after Bice and Stewart, 1990)

UNIT DESCRIPTIONS

Because the seamounts were at a significantly different water depth than the basins, and because carbonate sediments are excellent depth indicators, there is a clear facies difference between shallow-water seamount sequences and deep-water basinal sequences. The deep-water basinal facies have been represented as the 'Complete Sequences'; this includes the Corniola, Rosso Ammonitico, Marne a Posidonia, and Calcari Diaspri units (Alvarez and Montanari, 1988). In general, the basinal facies are characterized by thick deposits of radiolarian cherts and may contain slumps, pebbly mudstones, megabreccias, or turbidites. The 'Complete Sequence' is about 300 meters thick (Alvarez and Montanari, 1988).

In contrast, the shallow-water seamount facies have been characterized as 'Condensed Sequences,' which are thinly bedded, densely fossiliferous limestones. These may be only 50 meters thick, and, in some locations, represented by only one formation - the Bugarone (Alvarez and Montanari, 1988).

Both the basinal 'Complete Sequences' and the seamount 'Condensed Sequences' are overlain by the Maiolica Formation, a white, creamy, fine-grained pelagic limestone. It is thinly bedded and may be dolomitized at the base where it overlies a seamount, or thickly bedded and may contain slumps and gravity flows where it overlies a basin (Alvarez and Montanari, 1988). The 'basinal' Maiolica facies may be 200 meters thick; the seamount facies may be only 50 meters. Deposition of the Maiolica Formation partially leveled the seamount and basin topography; by the end of the Early Cretaceous the basin was essentially flat.

DISCUSSION

The Calcare Massiccio platform is composed of massive, fine-grained, thickly-bedded limestone. It is highly resistant, and makes up the cores of many of the large anticlines in the Umbria-Marches region of the Apennines. As the facies map (Figure 2) shows, the area around Monte Pietroso and Monte Scocione is no exception. The outcrops found in the part of the study area with the highest elevation are composed of the Calcare Massiccio, dolomitized Maiolica, and Bugarone units. The presence of the Bugarone Formation (a unit of the Condensed 'seamount' Sequences) in these locations suggests that the summits of Monte Pietroso and Monte Scocione may have been the tops of one or more seamounts in Jurassic and Early Cretaceous time. Furthermore, the dolomitization of the outcrops of Maiolica Formation on the top of Monte Scocione suggest that it might have been exposed alternately to air and water as it was being deposited. This supports the hypothesis that the top of Monte Scocione may have been the top of a seamount in Jurassic and Early Cretaceous time.

There are also three locations in the study area that are possible sites for the edges, or slopes, of one of these paleo-seamounts. The first two are on the northern and southern sides of Monte Scocione. In both cases, the outcrops consist of Calcare Massicio with small pockets of unbedded Bugarone Formation on them. Since the Bugarone is usually distinctly and thinly bedded on seamount tops, the lack of bedding here might suggest deposition on a slope, with synsedimentary deformation resulting in distorted bedding, or a post-depositional slide or slump. There are large outcrops of Calcare Massiccio and dolomitized Maiolica uphill from both of the 'pocket' outcrops. It is possible that the current topographical hillsides in each of these locations mimic the original paleoslope of the Jurassic seamounts. It is also possible that the pockets of Bugarone were tectonically emplaced either during a later phase of normal faulting in the Jurassic, or during the younger compressional orogeny.

The third possible location for a paleo-seamount slope is in the valley east of Monte Scocione and Monte Pietroso. This outcrop is located at an elevation of 550 meters, and is unique. The limestone here lacks bedding and contains fossils usually associated with the Bugarone Formation, which was deposited in the Early Cretaceous.Within this limestone are embedded clasts of Early Jurassic Calcare Massicco, which indicates that there was an exposed section of Calcare Massiccio uphill from this location at the time of deposition. The presence of both Early Cretaceous fossils and clasts of Jurassic-age limestone in the same outcrop strongly suggests the presence of a Mesozoic fault scarp with Calcare Massiccio exposed in the upthrown block.

CONCLUSIONS

The overall geography and relationship of the outcrops to one another suggest that the area around Monte Scocione and Monte Pietroso was once a Jurassic seamount. The outcrops on the highest portions of these mountains suggest the top of such a seamount. Outcrops on the hillsides below may represent the paleoslopes on the sides of this seamount.

Seamounts were defined and bound by a complex system of intersecting normal faults in Jurassic time. Because the Calcare Massiccio is such a highly resistant unit, Oligocene-Quaternary tectonism may have reactivated older extensional faults, as opposed to initiating new faults through the thick seamount blocks. Preliminary measurements suggest that Monte Pietroso and Monte Scocione are part of a large anticline that resulted from the Oligocene-Quaternary folding and thrusting. This large anticline may have deformed around a large seamount block in the area of Monte Pietroso and Monte Scocione.

REFERENCE CITED

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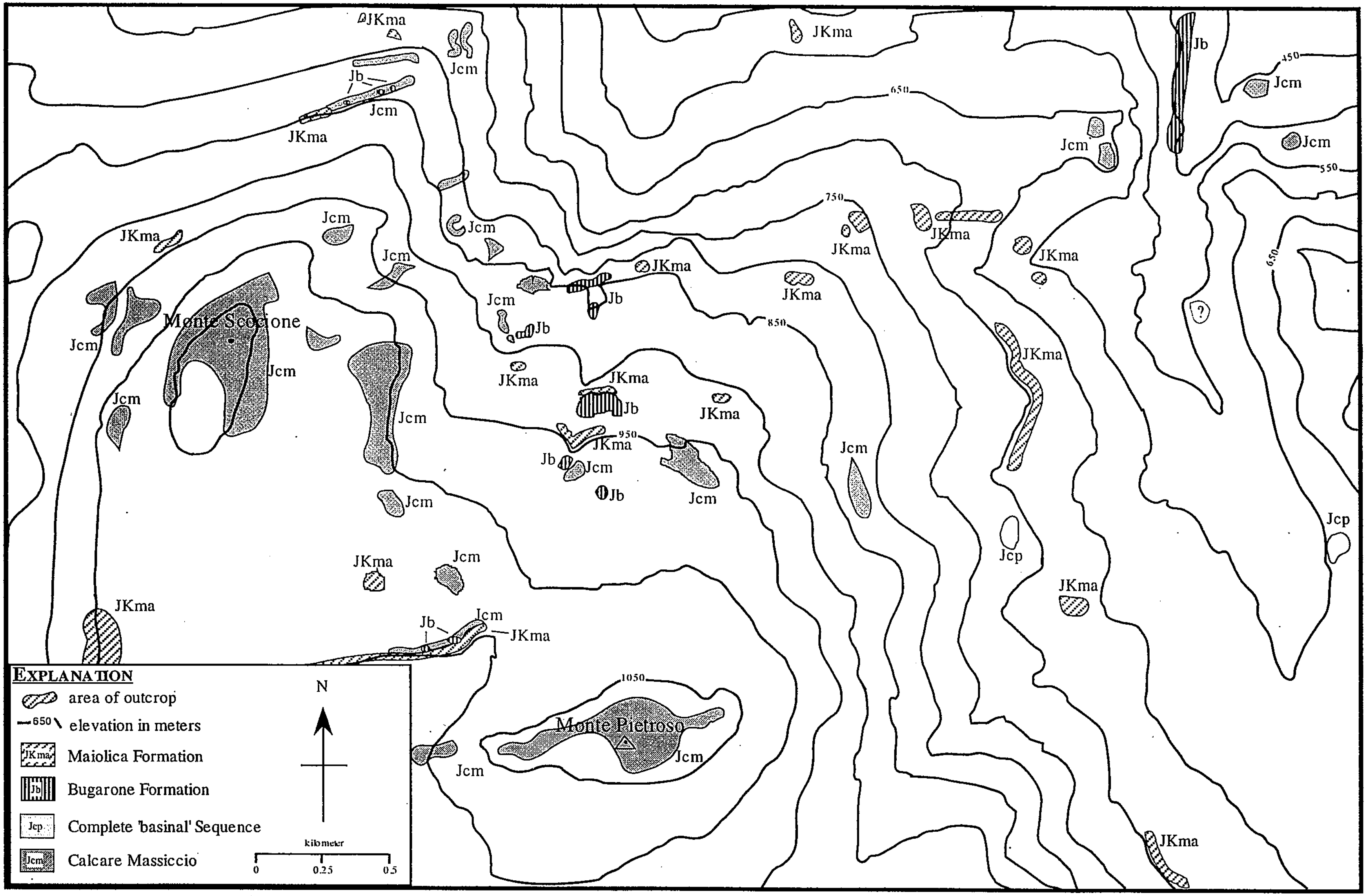

Figure 2. Outcrop Map of Jurassic carbonates near Monte Pietroso and Monte Scocione