Zeitschrift: Eclogae Geologicae Helvetiae
Herausgeber: Schweizerische Geologische Gesellschaft
Band: 72 (1979)
Heft: 3

Artikel: Jurassic pelagic deposits from Southeast Tuscany : aspects of sedimentation and new biostratigraphic data
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Kapitel: Introduction
DOI: https://doi.org/10.5169/seals-164859

Im unteren Toarcian wird der Calcare Selcifero durch eine vorwiegend mergelige Einheit - die Marne a Posidonia - abgelöst. Die assoziierten Resedimente bestehen ausschliesslich aus umgelagertem pelagischem Material. In den Marne a Posidonia beträgt die durchschnittliche Sedimentationsrate (inkl. Resedimente) lediglich noch um 2 mm / 1000 Jahre. Als Ursachen für diese drastische Reduktion der Sedimentationsrate betrachten wir a) das Aufhören der Zufuhr von neritischem Karbonatsediment, bedingt durch ein Absinken der umliegenden flachmarinen Liefergebiete in die aphotische Zone, und b) eine Intensivierung der Karbonatlösung am Meeresboden, infolge zunehmender Wassertiefe im Ablagerungsraum.

Im jüngsten Teil der Marne a Posidonia fanden wir eine Aptychen-Fauna mit Formen des Callovian (Brauner Jura ζ); wir schliessen daraus auf ein Einsetzen der Radiolarit-Sedimentation gegen Ende des Callovian. Die Radiolarite (Diaspri) lassen sich in vier Faziestypen gliedern, die sich in Schichtungstyp, sedimentären Strukturen, Texturen und Grad der Bioturbation unterscheiden. Es zeigt sich, dass die Sedimentation der Diaspri weitgehend durch marine Strömungen (Turbidity currents und Bottom currents) kontrolliert wurde. Das vollständige Fehlen von karbonatischem Material in Teilen dieser Einheit deutet auf ein Absinken des Ablagerungsraumes in den Bereich der damaligen Kalzit-Kompensationstiefe.

Die Diaspri werden von Aptychen-Schichten (Rosso ad Aptici) überlagert, deren Aptychen Formen des Tithons umfassen. Um die Jura/Kreide-Wende setzt die Sedimentation der Maiolica-Kalke ein.

CONTENTS

INTRODUCTION

In spite of the vastly increased knowledge of Alpine-Mediterranean Jurassic pelagic deposits in recent years, many problems have still not been completely resolved. For instance, surprisingly little detailed information is available on the widespread Alpine radiolarites, although they play a major role in current reconstructions of the preorogenic Tethyan palaeogeography. Indeed, the apparent uniformity of many radiolarites as well as their generally high degree of diagenetic alteration make them not very attractive for sedimentological investigations. Likewise, their age range is often uncertain, since diagnostic macrofossils usually are lacking and since there is still little known about the ranges of Jurassic radiolarian genera.

In this paper we intend to touch upon certain sedimentological aspects of some Jurassic continental-margin deposits from the Tuscan Apennines. Particular attention is paid to the sedimentary features of the radiolarites. In addition, a more precise age assignment of the radiolarites is attempted, based on aptychi recovered from siliceous limestones and shales occurring both immediately below and above the nearly calcite-free radiolarian cherts.

Geological frame

The Northern Apennines are built of several thrust-sheets transported towards the east and northeast. Two major groups of nappes are distinguished, the Ligurian and the Tuscan nappes with the former tectonically emplaced on the latter. The Ligurian nappes, comprising Early to Middle Jurassic ophiolites (BIGAZZI et al. 1972, 1973) and their sedimentary cover, generally are considered as derived from oceanic areas, which opened during Jurassic time in connection with sea-floor spreading in the Central Atlantic and along the Tethys (e.g. LAUBSCHER & BERNOULLI 1977). Likewise, the structural position and the preorogenic sedimentary evolution of the Tuscan units suggest that they were part of the Italy-Adriatic continental margin bordering the oceanic Tethys to the southeast.

In Northern Tuscany two superimposed Tuscan units can be clearly recognized beneath the Ligurian nappes. The lower one appears in two large tectonic windows in the Alpi Apuane and in the Monti Pisani further to the south. It usually is referred to as "Tuscan Autochthon", although it has been clearly demonstrated that it is, at least partially, allochthonous also (CARMIGNANI et al. 1978). This lower unit consists of Variscan folded Paleozoic and an overlying ? Permian to Oligocene sedimentary sequence, which during Tertiary were subjected to several phases of deformation and metamorphosed to greenschist facies. By contrast, the upper unit, called "Tuscan Nappe", is virtually unmetamorphosed and much less deformed internally. Its stratigraphy is comparable with that of the underlying "Tuscan Autochthon". However, the Tuscan Nappe comprises no rocks older than Upper Triassic as it has been sheared off along Norian evaporites and thrust towards the east, over the metamorphic unit. Originally, it most probably was located immediately to the west of the "Tuscan Autochthon" (BALDACCI et al. 1967).

Even though similar stratigraphic sequences reappear south of the Arno Valley, the overall structural pattern differs markedly from that observed to the north and no reasonable explanation has been given for this difference as yet. In Southern Tuscany, metamorphic Tuscan sequences including pre-Upper Triassic rocks are exposed on Elba Island and along a north-south trending belt extending from the Montagnola Senese to the Monte Argentario. Virtually unmetamorphosed (anchi- to non-metamorphic) sediments of the Tuscan Mesozoic cover, again displaced differentially with respect to their original pre-Upper Triassic substratum, occur on Elba overlying a metamorphic sequence and, on the mainland in a number of scattered and isolated outcrops both west and east of the metamorphic terranes. However, unlike the situation north of the Arno River, the non-metamorphic sequences obviously do not combine laterally into a continuous nappe. Particularly in the internal area, between the Tyrrhenian coast and the Montagnola Senese, they can be seen to form part of several isolated lenticular bodies underlying the Liguride complex. Eastwards from the Montagnola Senese, the non-metamorphic Tuscan Mesozoic cover becomes more continuous and, at the same time, roughly east-verging compressive structures arise. Conventionally these features have been suspected to indicate a gravitational eastward movement of the unmetamorphosed Tuscan cover beyond the metamorphic terranes. In this view, the internal area would represent the tectonically denudated source area with isolated remnants of its

Mesozoic cover left behind (e.g. GIANNINI & LAZZAROTTO 1975). However, evidence hardly consistent with this concept is increasing. For instance, our own sedimentological investigations on the non-metamorphic Jurassic deposits in Southern Tuscany revealed that the sequences in the area internal to the Montagnola Senese differ remarkably from those located externally, and that the latter bear a conspicuous resemblance to the sequences deposited in the contiguous Umbrian realm. At present, however, data are still too scarce to allow the establishment of a more accurate picture of the original spatial relationship between the metamorphic and the non-metamorphic Tuscan terranes and the nature of the transition to the Umbrian zone.

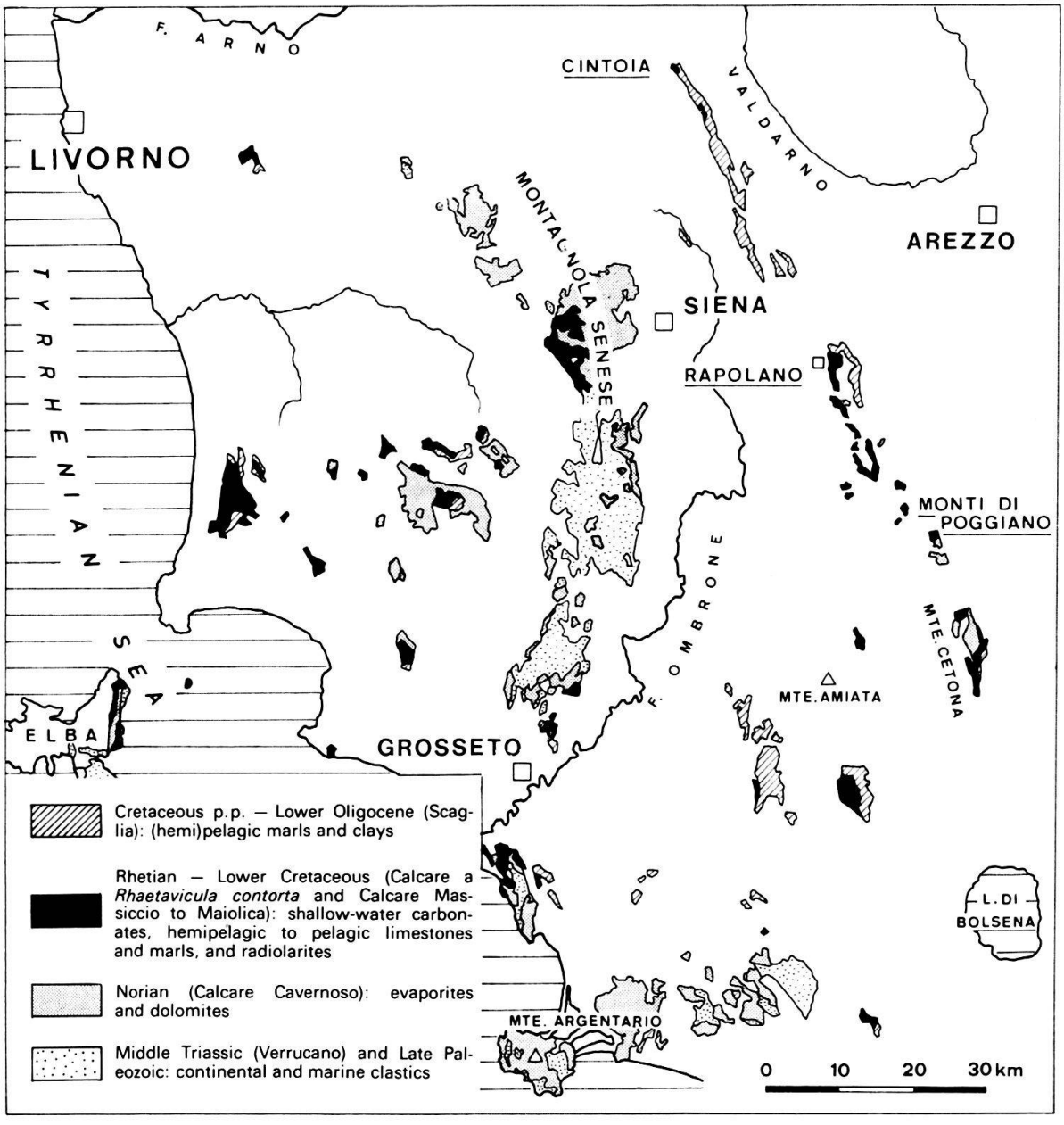

Fig. 1. Outcrops of Tuscan sediments south of the Arno River and location of the studied area.

During the latest Triassic and the earliest Jurassic, the Tuscan belt was covered by shallow-water carbonates, as were vast parts of the future marginal areas of the Alpine-Mediterranean Tethys. By the late Hettangian/Sinemurian, conspicuous tensional faulting occurred, supposedly induced by early rifting. As a consequence of block-faulting, much of the former carbonate-platform area was submerged and pelagic conditions became widespread. Marked lateral variations in facies and thickness of the hemipelagic and pelagic deposits overlying the shallow-water carbonates reflect deposition in an area of pronounced submarine relief, resulting from differential subsidence of individual fault-blocks. The overall vertical lithologic evolution, featuring increasing effects of carbonate dissolution, suggests a continuous deepening of the sea floor to near and even below the compensation depth of calcite throughout the Jurassic Period (e.g. BERNOULLI et al. 1979).

In Southern Tuscany, the Jurassic part of the Tuscan sequence is conventionally divided into six formations, whose stratigraphic extent is only approximately known. The following subdivision is commonly used (e.g. BORTOLOTTI et al. 1970; DALLAN NARDI & NARDI 1974):

— *Calcare Massiccio,* a typical shallow-water limestone, traditionally attributed to the Hettangian and the lowermost part of the Sinemurian.

— *Calcare Rosso Ammonitico,* red nodular limestones of Sinemurian/Carixian age, which represent the first widespread pelagic sediment.

— *Calcare Selcifero,* grey hemipelagic to pelagic limestones, often with marly interlayers and redeposited beds. This formation is generally thought to comprise part of the Middle Liassic and the Upper Liassic.

— *Marne a Posidonia,* mainly red (hemi)pelagic marls, commonly allocated to the Middle Jurassic.

— *Diaspri,* thin-bedded, greenish, red or dark-coloured radiolarian cherts with interbedded argillites, and aptychus-bearing siliceous limestones and marls. The Diaspri are considered to include a major part of the Upper Jurassic.
In Southern Tuscany, the aptychus beds often appear as a well-developed and distinctive lithostratigraphic unit, above interbedded cherts and shales. We thus propose to reserve the term "Diaspri" for the lower calcite-free or merely slightly calcareous radiolarites and to call the aptychus beds *"Rosso ad Aptici"*, in accordance with the stratigraphic terminology applied in the Southern Alps.

— *Maiolica,* light-coloured coccolith limestones, ranging in age from the uppermost Jurassic to the Barremian. Generally the thicknesses of the Maiolica limestone are low throughout Southern Tuscany. In places this facies is lacking completely or is replaced by a sedimentary breccia with white coccolith limestone occurring as matrix and/or components (Monte Cetona area).

Location of sections

The outcrops dealt with in this paper are amongst the easternmost occurrences of Tuscan Mesozoic sediments. They are aligned along the cores of a NNW-SSE trending belt of fold structures verging to the east (Fig. 1, 2).

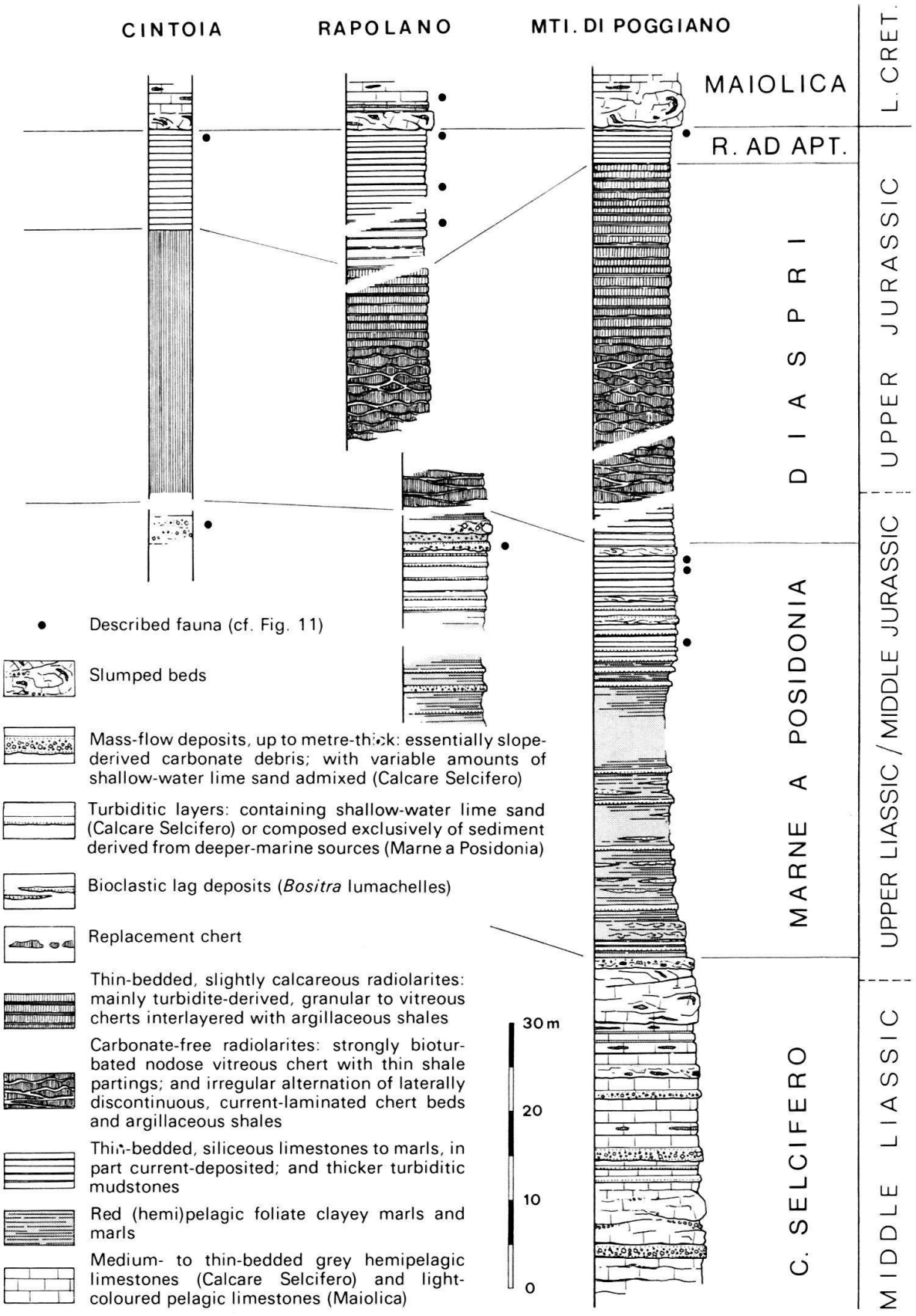

Fig. 2. Columnar sections of basinal sequences from Southeastern Tuscany.

In the *Monti di Poggiano*, situated about 2 km west of Montepulciano, an almost complete Middle Liassic to Lower Cretaceous sequence is exposed in several adjacent quarries. The geological situation and the local stratigraphy have been described already by LOTTI (1910), LOSACCO & DEL GIUDICE (1958), FAZZINI et al. (1968) and PAREA (1970). The measured section begins somewhere in the Calcare Selcifero, which is conformably overlain by the Marne a Posidonia, the Diaspri, a few metres of Rosso ad Aptici and, finally, by about 15 m of Maiolica limestone. Both, the upper part of the Marne a Posidonia and the Rosso ad Aptici provided determinable aptychi (see below).

In the *Rapolano area*, previously studied by DE ANGELIS D'OSSAT (1879), LOSACCO (1951), LOSACCO & DEL GIUDICE (1958) and CANUTI & MARCUCCI (1967), no continuous section is exposed, but part of the Jurassic sequence could be reconstructed from different outcrops. Our data are mainly drawn from two localities: 1. Near Podere Monte Camerini, about 1 km southeast of Rapolano, we surveyed the upper part of the Marne a Posidonia. A conglomeratic layer found at about 3 m below the top of the formation yielded abundant aptychi. The Diaspri, though outcropping in a number of abandoned quarries in the same area, generally appeared too weathered to allow a detailed investigation. 2. Relatively fresh exposures of radiolarites, aptychus beds and Maiolica limestone occur along the state road No. 326, immediately east of Rapolano. The continuity of the section is repeatedly interrupted by faults, but nevertheless an almost complete Upper Jurassic sequence could be compiled. From these outcrops the major part of the Tithonian aptychus assemblage described below was collected.

In the *Chianti region*, northeast of Siena, Jurassic sediments appear only in few, small outcrops near Cintoia and further south, near Lucolena. Accounts dealing with their stratigraphy have been published by VALDUGA (1948), BORTOLOTTI & PASSERINI (1965) and CANUTI et al. (1965). We attempted no detailed study of this area, but a cursory reexamination of the localities referred to by these authors revealed that the mainly Upper Jurassic deposits exposed compare well lithologically with those in the above areas. At Borro di Cafaggio, southwest of Cintoia, we found some aptychi both in a slide conglomerate underlying the Diaspri and near the top of the Rosso ad Aptici.

LITHOLOGY

Calcare Selcifero

The lowest lithologic unit considered in this study consists of well-bedded, slightly siliceous grey calcilutites with intercalated resediments. Limestone beds are separated by thin, dark-grey marly or greenish clayey interlayers. Towards the top of the formation somewhat thicker, reddish marl interbeds occur and in general the limestone/marl transitions become more gradual. However, locally the limestones display somewhat nodular surfaces. In this upper part of the Calcare Selcifero, replacement chert tends to be more frequent. The sediment generally appears thoroughly mottled; bioturbation has led to a complete destruction of primary sedimentary structures. Particles of coarse silt and sand grade, which are mainly