Review of Palaeobotany and Palynology 218 (2015) 67–79

Contents lists available at ScienceDirect

Review of Palaeobotany and Palynology

journal homepage: www.elsevier.com/locate/revpalbo

Palynostratigraphy and palynofacies of the Upper Triassic Streppenosa Formation (SE Sicily, Italy) and inference on the main controlling factors in the organic rich shale deposition

Simonetta Cirilli [a,*], Nicoletta Buratti [a], Luigi Gugliotti [b], Alfredo Frixa [b]

[a] Dipartimento di Fisica e Geologia, Università di Perugia, Via Pascoli, 06123 Perugia, Italy
[b] Eni E&P, Via Emilia 1, San Donato Milanese, Milano, Italy

ARTICLE INFO

Article history:
Received 23 April 2014
Received in revised form 16 September 2014
Accepted 17 October 2014
Available online 23 January 2015

Keywords:
Triassic
Palynofacies
Palynostratigraphy
Organic matter
Sicily
Streppenosa Formation

ABSTRACT

This paper focuses on the Upper Triassic Streppenosa Formation, penetrated by the Pachino 4 on-shore well, (Southern Sicily, Italy) in order to find stratigraphic age constrains and to reconstruct the paleoenvironmental evolution of this basin within the Upper Triassic palaeogeographic scenario of the western Tethys. Pachino 4 is one of the wells drilled by Eni Exploration and Production in the south-eastern Hyblean plateau with the purpose to better define the time and space distribution of reservoirs and source rocks in an area characterized by considerable subsidence and strong tectonic activity, balanced by high sedimentation rate. The Streppenosa Formation depocenter consists of a thick sequence (>2500 m) of organic rich shales, turbiditic limestones and marly limestones, grouped into three members (Lower, Middle and Upper). The well diversified microflora assemblages allow the dating of the upper part of the Lower Member and the Middle Member as Norian and the Upper Member as Rhaetian. The palynofacies variations across the Streppenosa Formation show significative changes in the relative abundances of the organic debris that, associated with the lithological and sedimentological features, allowed a reconstruction of the depositional facies successions and a hypothesis for the forcing mechanisms driving the black shale deposition. We considered that the deposition of the Streppenosa Formation occurred in an epeiric basin, under oxygen-depleted bottom waters, with different depth that varied through time in response to the sedimentation rates, eustatic sea level changes, and basin subsidence. The integration of palynofacies and lithofacies data suggests a crucial role for river runoff, responsible for water stratification and for primary productivity increase in the water column. The process was triggered by warmer and wetter climate conditions as documented in many Upper Triassic successions of the western Tethys realm.

1. Introduction

Large fluctuations in the early Mesozoic climate are usually linked to widespread deposition of organic carbon rich sediments. In the western Tethys evidence of increasing humidity and seasonality around the Triassic–Jurassic (Tr–J) boundary have been documented by the large amount of enriched organic matter and shaly sediments deposited within low dysoxic–anoxic basins (e.g., Hallam, 1985; Berra and Cirilli, 1997; Cirilli et al., 1999; Wignall, 2001; Buratti and Cirilli, 2007; Bonis et al., 2010a). The beginning of black shale deposition seems to coincide with the onset of a negative $\delta^{13}C$ excursion (Kürschner et al., 2007; Bonis et al., 2010a, 2010b; Ruhl et al., 2011) just before the Tr–J boundary. This boundary is marked by major environmental and biotic changes assumed to be coeval with perturbations of the global carbon cycle, thus suggesting sudden input into the ocean–atmosphere system of large amount of CH_4 or CO_2. Two distinct negative organic Carbon Isotope Excursions (CIE) both in carbonates and organic matter were recorded in many sections within and outside the Tethys Ocean (Hesselbo et al., 2002; Galli et al., 2007; McElwain et al., 2007; Götz et al., 2009; Clemence et al., 2010; Deenen et al., 2010; Michalík et al., 2010; Ruhl et al., 2011; Schaller et al., 2011; Steinthorsdottir et al., 2011; Lindström et al., 2012; Dal Corso et al., 2014). The short-lived "initial" CIE concurs with the major end-Triassic biotic turnover and is separated from the longer-lived "main" CIE by a return to Rhaetian base values (Hesselbo et al., 2002). The onset of the main CIE coincides with the base of the Jurassic, which is defined by the first occurrence of the *Psiloceras spelae* ammonite species (von Hillebrandt et al., 2007). At the Tr–J transition it has been recently argued that changes in the bulk C-isotope composition of the sedimentary organic matter are largely controlled by changes in type of organic matter (van de Schootbrugge et al., 2008). Still matter of debate is instead the forcing mechanisms that have been invoked to explain the environmental and biological changes at the Tr–J transition. According to several researchers the onset of the Central Atlantic Magmatic Province (CAMP), related to the break-up of Pangaea, could have triggered the biotic crisis by releasing of volcanic gases (mainly CO_2 and SO_2) into the ocean–

* Corresponding author.
E-mail address: simonetta.cirilli@unipg.it (S. Cirilli).

http://dx.doi.org/10.1016/j.revpalbo.2014.10.009
0034-6667/

atmosphere system (Hesselbo et al., 2002; Schaltegger et al., 2008; van de Schootbrugge et al., 2008, 2009; Cirilli et al., 2009; Deenen et al., 2010; Schoene et al., 2010; Marzoli et al., 2011; Ruhl et al., 2011; Schaller et al., 2011; Lindström et al., 2012; Pálfy and Zajzon, 2012; Mander et al., 2013).

The present study shows high resolution palynological proxy records from the Upper Triassic Streppenosa Formation (SE Sicily, Italy). During the past decade, palynology has generated considerable interest in the field of petroleum exploration for its great potential in stratigraphic, palaeogeographic, palaeoenvironmental and palaeoclimatologic studies. Integrated high resolution palynostratigraphy and palynofacies data were used in this study to constrain the age, type and source of sedimentary organic matter and the associated history of environmental changes.

2. Geological setting and palaeogeography

Southern Italy is an interesting and promising area for hydrocarbon exploration. Some wells have been drilled by Eni E&P in the Hyblean plateau with the aim to better define the time and space distribution of reservoirs and source rocks in the SE Sicilian on-shore and off-shore (Trincianti et al., 2015). The main targets were represented by the hydrocarbon-bearing Triassic and Jurassic carbonates, in the different wells. The Hyblean plateau was characterized by carbonate sedimentation, between the Mesozoic to Miocene. It was successively involved in foreland and foredeep chains as the result of Alpine collision between the African and the European plates (Patacca et al., 1979; Brosse et al., 1988, 1990; Yellin-Dror et al., 1997).

During the Norian–Rhaetian times two different palaeogeographic domains developed within the Hyblean area (Fig. 1), characterized by different subsidence and sedimentation rates (Frixa et al., 2000). Shallow water depositional environments and lower subsidence rate affected the northern part of the Hyblean plateau (i.e., Noto 1 well). In the Norian, the area was characterized by the dolomitic peritidal sedimentation of the Sciacca Formation (coeval to the Dolomia Principale Formation, lower-middle Norian). During the end of Rhaetian the Noto area began to drown and although the subsidence was less pronounced with respect to the southern area, a shallow euxinic lagoon/basin settled. The Noto Formation, dated as Rhaetian by palynological data (Frixa et al., 2000), consists of alternation of black shales and micritic, microbial dolomitic limestones (average thickness about 200 m). In this area the absence of a recognized stratigraphic continuity (Upper Norian–Lower Rhaetian) between the Sciacca Formation and the Noto Formation has been interpreted as a sedimentary gap (Frixa et al., 2000).

In the southern sector (penetrated by the Marzamemi 1, Pachino 4 and Polpo 1 wells), the tectonic activity was more pronounced and the considerable subsidence was balanced by high sedimentation rate. Here the organic rich basinal shales and limestones of the Streppenosa Formation were deposited under prevailing reducing conditions. The Lower Streppenosa Member, whose base has never been reached by any wells, has been attributed to the Norian–Rhaetian by calcareous nannofossils, (Frixa et al., 2000). The thick basinal sequence (about 2000 m) of the Middle Streppenosa Member has been mostly referred to the Rhaetian and the Upper Streppenosa Member has been dated as Hettangian in Frixa et al. (2000).

In correspondence of the boundary between the two different domains (to the North the euxinic lagoon/basin of the Noto Formation, and to the South the basin of the Streppenosa Formation), a complex of carbonate microbial mounds with associated breccias forms the Mila Member of the Noto Formation (Fig. 1). The Mila Member represents a narrow backstepping platform margin separating the Noto Formation from the Rhaetian portion of the Streppenosa Formation (Middle Streppenosa Member). This member is divided into two partially overlapping units. The older unit (Lower Mila Member) lies above the carbonate platform of Sciacca Formation (Fig. 1), while the younger lies in part above the Lower Mila Member and in part above the Noto Formation (Frixa et al., 2013).

Around the Rhaetian–Hettangian boundary a marine transgression allowed the deposition of the euxinic basinal sediments (Upper

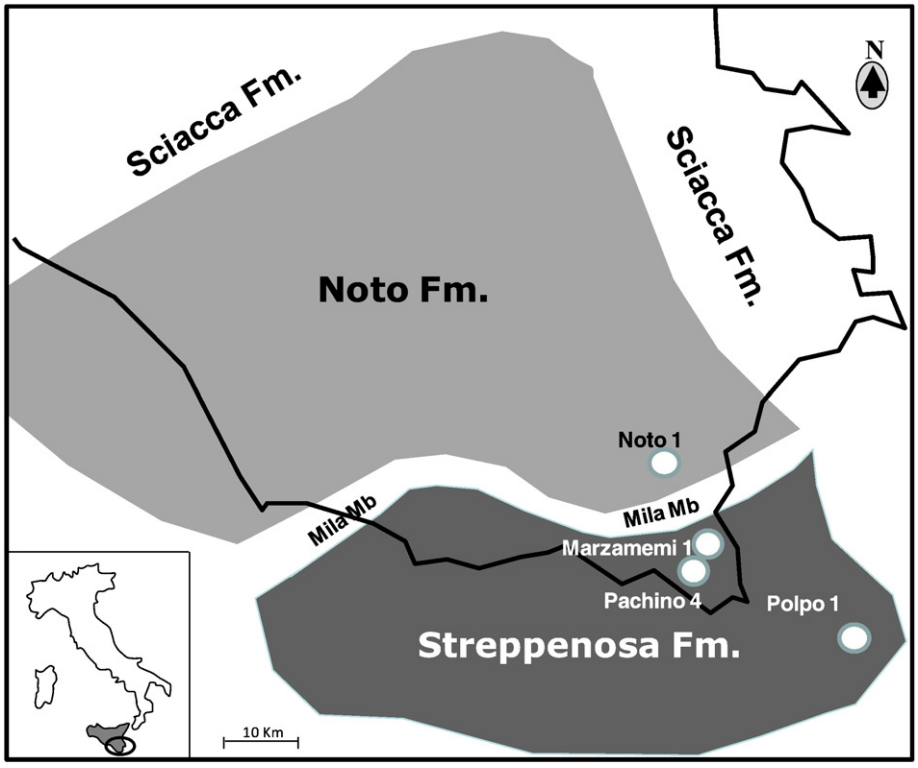

Fig. 1. Palaeogeographic domains and facies distribution in the Hyblean Plateau during the Late Triassic. Sciacca Formation, shallow water carbonate platform; Noto Formation, euxinic lagoon; Mila Member, algal mounds marginal complex; Streppenosa Formation, anoxic–dysoxic. Circles: some of the drilled wells by Eni E&P.