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Middle Jurassic vegetation dynamics from allochthonous palynological assemblages: An example from a marginal marine depositional setting; Lajas Formation, Neuquén Basin, Argentina

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ABSTRACT

Middle Jurassic marginal marine sediments from four successions within the Lajas Formation, Neuquén Basin, Argentina, were analysed to establish their palynofloral composition. The palynofloras, mostly of terrestrial origin, are characterised by a dominance of *Classopollis* spp. and common *Pityosporites* spp.; *Deltoidospora* spp.; Araucariaceae and inaperturate pollen. Correspondence analysis performed on the palynomorph assemblages derived ecological groupings characteristic of a number of palaeoenvironments from coastal/deltaic, river margins and floodplains, to higher altitude arid forests. The ecological groupings differ between the four studied successions indicating a dynamic ecosystem. Delta top depositional settings have ecological groupings characteristic of mid-late seral communities, whereas delta front and bayfill depositional settings have ecological groupings displaying early-mid seral communities. This study discusses the taphonomic and palaeoecological reasons for these changes in palaeoecological grouping.

The relationships between natural ecological groupings of taxa determined using correspondence analysis provide evidence for the first order drivers of vegetation dynamics. Water availability and environmental stress (substrate disturbance) are proposed as the most important drivers of palaeofloral seral succession during the Middle Jurassic of the Neuquén Basin. This relationship between floral communities and their palaeoenvironment can be related to the ecological parameters of modern floras suggesting that similar ecological drivers control palaeofloral assemblages as far back, at least, as the Middle Jurassic.

The process used herein provides a thorough methodology of understanding floral palaeoecologies and drivers of seral succession in plant communities from allochthonous materials in marginal marine depositional settings. From this, a greater understanding of the depositional environment can be derived through the appreciation of taphonomic processes.

1. Introduction

The Neuquén Basin of western Argentina (Fig. 1) was formed during the Late Triassic to Early Jurassic by thermo-chemical collapse of a thickened late Palaeozoic crust (Franzese and Spalletti, 2001; Franzese et al., 2006). After an initial stage of sedimentation, which included the deposition of epiclastic volcanic sediments and continental red-beds, a widespread transgression during the Pliensbachian stage caused marine conditions to prevail across the basin (Legaretta and Uliana, 1991), although marine conditions are reported in the North of the basin earlier in the Hettangian (Riccardi et al., 1997). These conditions persisted until structural inversion during the Callovian, which led to a brief but widespread unconformity as the basin became isolated from the Pacific Ocean and parts of the basin became uplifted (Legaretta and Uliana, 1991; Legarreta and Uliana, 1996). Marine connections returned by the Late Callovian (Howell et al., 2005; Riding et al., 2011).

The Lajas Formation forms part of the Middle Jurassic Cuyo Group (Fig. 2). The underlying Los Molles Formation is characterised by a thick succession of turbiditic sandstones and pelagic shales (Gulisano and Gutiérrez Pleimling, 1994; Burgess et al., 2000; Martínez et al., 2008). The shelfal sediments of the Lajas Formation overlie the Los Molles Formation (Gulisano and Gutiérrez Pleimling, 1994; McIlroy et al., 1999, 2005; McIlroy, 2007) which in turn is overlain by fluvio-lacustrine sediments of the Challacó Formation and the evaporite rich Tábanos Formation further north in the basin (Fig. 2, Legaretta and Uliana, 1991). The Lajas Formation is thickest and oldest towards the south-east where it was deposited within a structurally bound embayment over 100 km wide on the southern margin of the Neuquén Basin (McIlroy et al., 2005).

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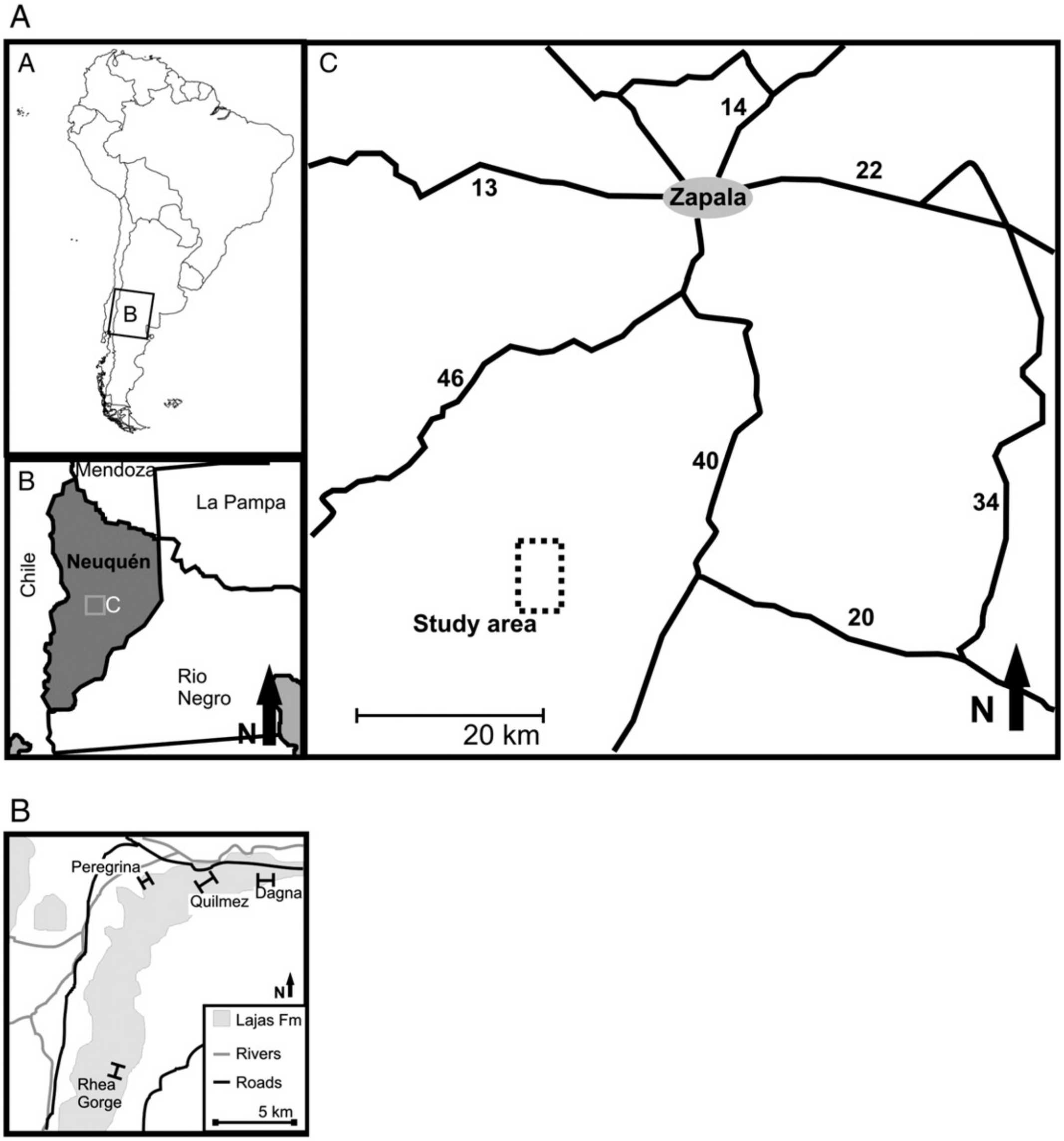

Fig. 1. A: Location diagram of study area. A shows the location of map B in the context of South America. B shows the Neuquén Province and map C. C. is a map south of Zapala showing the Sierra de Chacaicó study area. B: Location of sampled sections within the Sierra de Chacaico outcrops (Fig. 1).

Recent study of the Bajocian Sierra de Chacaico outcrops documented a range of marginal marine and deltaic facies with a strong tidal influence (McIlroy et al., 1999, 2005). This work builds on a pre-established facies scheme and sequence stratigraphic framework (McIlroy et al., 1999, 2005; McIlroy, 2007). Palaeovegetation reconstructions for the Middle Jurassic Cuyo Group of the Neuquén Basin have previously been presented (Quattrocchio et al., 2001, 2007; Martínez et al., 2008). These models link macrofossil studies and palynofloras to palaeo-elevation and bedrock geology (acidic basement, terrestrial and marginal marine). The models however, are limited by their two-dimensional consideration of the ecosystems and a static range of ecological space applied to each of the floral groups.

The Sierra de Chacaico study area (Fig. 1) comprises cliff sections of ~48 km in length and many small gorges that allow three-dimensional control on lithofacies distributions within the outcrop succession (McIlroy et al., 1999). Four short stratigraphic sections (Peregrina parasequence set, the Quilmez parasequence, the Norwegian parasequence in Rhea Gorge and the Dagna parasequence; see Fig. 1B and McIlroy et al., 2005) were chosen to encompass a variety of depositional facies at different stratigraphic positions within the Lajas Formation (Fig. 1B).

The sedimentological understanding of tide-dominated deltas has progressed significantly in recent years (Martinius et al., 2000; McIlroy, 2004; Brandsaeter et al., 2005; McIlroy et al., 2005; McIlroy, 2007; Ichaso and Dalrymple, 2009). This calls for a reassessment of earlier studies of palaeofloral characteristics of both the delta top palaeoenvironments and also hinterland from which the sediment is derived (Martínez et al., 2002 and references therein). The significance of tide-dominated and tide-influenced deltas stems from their importance as petroleum reservoirs, especially offshore Mid-Norway (Martinius et al., 2000; McIlroy, 2004; Ichaso and Dalrymple, 2009) and the Northern North Sea (Maxwell et al., 1999). Facies characterisation and palaeoenvironmental interpretation is notoriously difficult in tide-influenced deltaic deposits (Martinius et al., 2011). Full integration of sedimentological and ichnological data has already been applied to facies analysis in the studied sections (McIlroy et al., 2005), but palaeoenvironmentally, rather than biostratigraphically, focussed palynological studies are lacking.