# Long-distance correlations in the Valanginian-Hauterivian: Argentina — Western Mediterranean — NW Europe

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Rawson, P.F. Long-distance correlations in the Valanginian-Hauterivian: Argentina — Western Mediterranean — NW Europe. — Scripta Geol., Spec. Issue 3: 151-158, 2 figs., Leiden, December 1999.
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Keywords: Ammonites, Argentina, Mediterranean area, NW Europe, Early Cretaceous.
Despite the considerable differences in faunas from three widely separated areas in the Early Cretaceous world (Argentina, the Mediterranean area and NW Europe) eight genera are common to all three: *Valanginites, Olcostephanus, Karakaschiceras, Neohoploceras, Neocomites, Oosterella, Spitidiscus,* and *Crioceratites.* Across two well-marked intervals (mid Valanginian and mid Hauterivian) the faunas are sufficiently close to allow correlation across the whole area. These represent intervals of global sea-level rise.

## Contents



## Introduction

The three areas that this paper considers represent a S-N transect of the Early Cretaceous world.The Neuquén Basin of West Central Argentina lay at a palaeolatitude of between some 33-38° S (only some 2° N of its present position), the West Mediterranean region straddled the 30° N line of latitude, while the NW European basinal system (North-Sea/North German basins) extended from about 40° to 48° N (Fig. 1). Their geological settings differed too. The West Mediterranean region formed part of the northern margin of Tethys, connecting westward with the Caribbean/Central America region and south-eastwards with the Himalayan/Madagascan area.The Neuquén and NW European basins were shallower and more restricted. The Neuquén Basin was a back-arc basin opening to the Pacific, while the NW European basinal system connected primarily with the Boreal seas to the north while maintaining more intermittent faunal connections with Tethyan areas to the south.

Hence it is not surprising that there are considerable differences in the ammonite faunas from one area to another. What is surprising is that some genera are common to all three areas and provide clues for a very long-distance correlation. Their occurrence and significance in correlation are discussed below.

## The faunal sequences

### The Neuquén Basin

The Valanginian to lower Barremian succession has been documented by Aguirre-Urreta & Rawson (1997, 1998), who have produced a detailed zonation (Fig. 2) based on a total of 16 sampled sections, mainly in the middle of the basin. The faunas consist of widely distributed (Tethyan-derived) and more regional (mainly Andean) genera. Diversity is low — at most levels the fauna is monogeneric.

Correlation with the standard sequences of the West Mediterranean region is difficult, but there are some levels where it can be attempted with confidence (Fig. 2) — based mainly on some of the genera that are common to all three basins.


Fig. 1. Location of the three basins: Valanginian reconstruction (map modified and redrawn from Rawson, 1993, fig. 10.1).

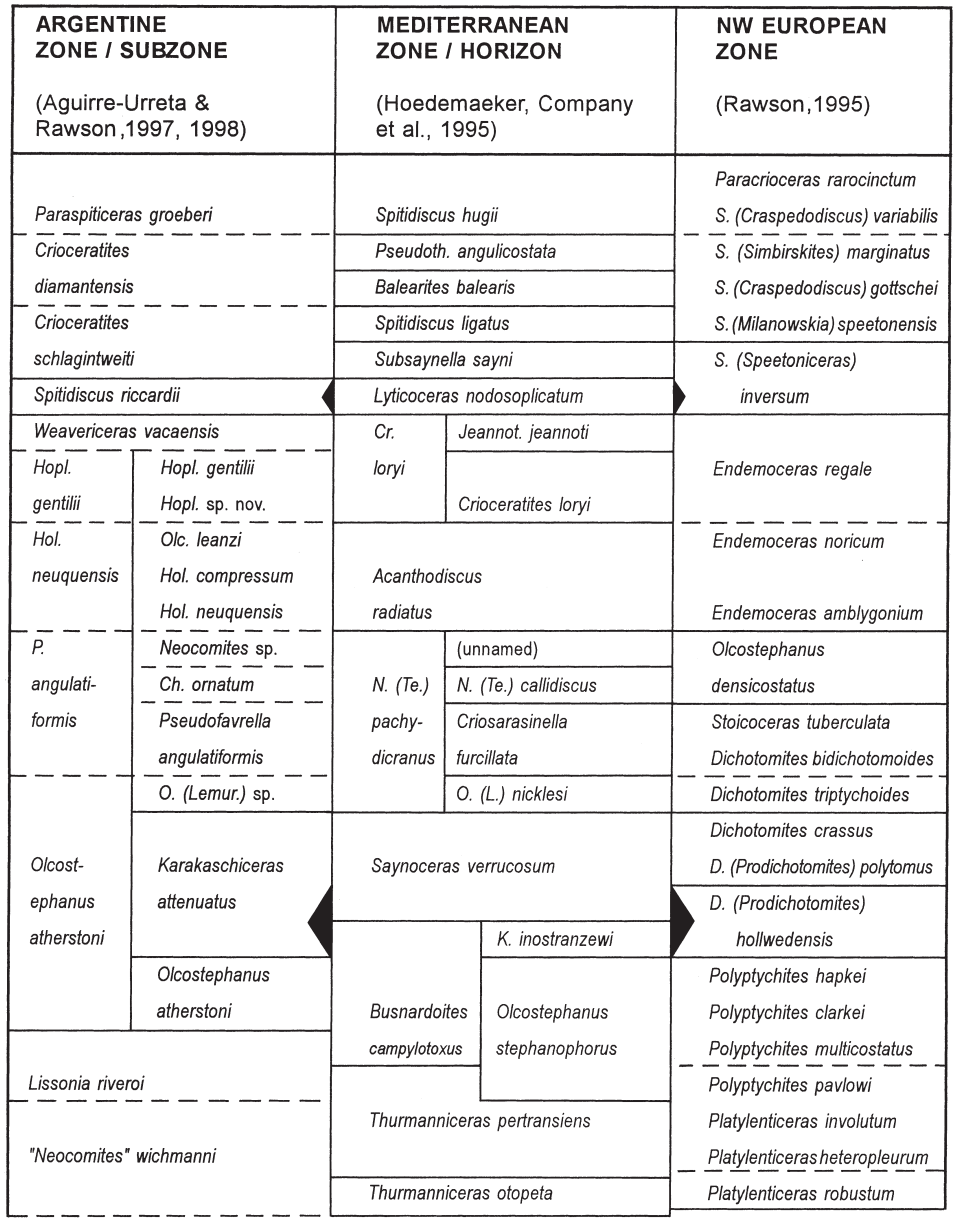


Fig. 2. Zonal schemes for Argentina and NW Europe and their correlation with the standard Mediterranean zonation.

Note: The Mediterranean scheme is based on the Working Group's agreed scheme; the alternative zonation of Bulot & Thieuloy (1995) for part of the Valanginian is also indicated. Correlation of Argentine and Mediterranean sequences follows Aguirre-Urreta & Rawson (1997, 1998), who correlated with Bulot & Thieuloy's (1995) scheme; that of the NW European and Mediterranean sequences follows Rawson (1995). Solid lines indicate confident correlation of either basin with the Mediterranean scheme, dashed lines indicate uncertainty. Correlation across the whole table, from Argentina to NW Europe, is only implied at the two intervals indicated by solid arrows.

### The Mediterranean area

At generic level, the faunas of this area are the most diverse so far documented. On a broad timescale, Rawson (1981, p. 515) noted that of the c. 55 Hauterivian genera then known, as many as 25 (45%) were recorded from the south-east of France. At the specific level, detailed range charts have been published for both individual and synthetic sections (e.g. Bulot & Thieuloy, 1995; Company, 1987; Hoedemaeker & Leereveld, 1995; Reboulet, 1995). Some of these include data on specific diversity. This wealth of distributional detail has formed the basis of a revised biostratigraphy of the region (Table 1) by our Working Group (Hoedemaeker et al., 1993).

While most of the ammonites of the Mediterranean area are typical Tethyan forms, Boreal immigrants occur at some levels.

### The NW European (North Sea/North German) basin

An extensive Early Cretaceous marine basin covered the present day North Sea area and extended eastward across much of northern Germany. Deposits of the western marginal area are exposed in eastern England, while there are more extensive (though often temporary) exposures in North Germany. The ammonite faunas are predominantly of Boreal origin, having much in common with those of the Barents shelf, Russian Platform and northern Siberia. But Tethyan immigrants occur at a number of levels through the Valanginian to Barremian sequence (see Rawson, 1995, for review), and together with Boreal immigrants to the Mediterranean area provide a means of correlating the two areas.

The Valanginian zones shown in Table 1 are based on the North German basin, where the sequence is much more complete; the Hauterivian to Barremian ammonite successions are very similar across the whole area. At many levels the faunas are essentially monogeneric, while at others several genera co-occur — especially where Tethyan immigrants appear.

## Long-distance correlation

Historically, the Tethyan ammonite zonation of the Mediterranean area has been regarded as the global standard with which other sequences should be correlated as far as possible. Thus both the Argentine and NW European sequences have been correlated independently with this geographically intervening standard. While this can in turn indicate possible indirect correlations between Argentina and NW Europe, the occurrence of several ammonite genera common to all three areas provides a key to some firmer, long-distance correlations. But some anomalous distributions also occur among these forms.

The genera in common to all three areas are: *Valanginites, Olcostephanus, Karakaschiceras, Neohoploceras, Neocomites, Oosterella, Spitidiscus*, and *Crioceratites*. Most of these achieved an almost global distribution, though with the exception of *Crioceratites* in Arctic Canada (Jeletzky, 1964) they failed to penetrate the most northerly part of the Boreal Realm —the Arctic Region. Some had a short temporal range, others lived for several million years. Their use and limitations in correlation from Argentina to NW Europe are discussed below.

### *Valanginites*

*Valanginites* is a distinctive, short-ranged olcostephanid that is best documented from the Mediterranean Region (Bulot, 1990; Company, 1987) and NW Europe (Kemper et al., 1981). There it is limited to a sequence of rocks spanning the lower/upper Valanginian boundary and (with associated *Karakaschiceras* and *Neohoploceras*) forms a particularly useful inter-regional marker. It is also known from Mexico and Colombia, where its stratigraphy has proved difficult to interpret in relation to the European sequences (but see discussion below).

From Argentina, Leanza & Wiedmann (1989) described a single *V. argentinicus* from the Vaca Muerta Formation. This is well below the first rich *Olcostephanus* and *Karakaschiceras* faunas there, and thus seems anomalously low compared with the European records. Aguirre-Urreta & Rawson (1998) have now discovered another 12 specimens at two localities and confirmed that the taxon occurs at one thin level in the highest part of the basal Valanginian Zone of *Neocomites wichmanni*, i.e. just below the zone of *Lissonia riveroi*.

### *Olcostephanus*

This is a long-ranged genus, appearing early in the Valanginian and dying out in mid-Hauterivian times. But in the European Valanginian there were two 'blooms', one in mid-Valanginian times and the other at the end of the Valanginian (Kemper et al., 1981; Bulot, 1990). In the Neuquén Basin the genus appeared suddenly and in abundance to provide the index fossil of the *atherstoni* Subzone. These *atherstoni* forms extend into the lower part of the overlying *attenuatus* Subzone. They appear close to the European *O. guebhardi* (Bulot, in Aguirre-Urreta & Rawson, 1997), indicating a possible correlation with the middle part of the Mediterranean *stephanophorus* Zone, where *O. guebhardi* reached its acme (Bulot & Thieuloy, 1995, table 2). Large examples are also close to the large, inflated *Olcostephanus* figured by Kemper et al. (1981) from the base of the *hollwedensis* Zone of North Germany.

Higher in the Argentine sequence a distinctive fauna of evolute forms appears, originally described by Leanza (1958) as *Simbirskites*. These are now placed in the *Olcostephanus* subgenus *Lemurostephanus*, and indicate a possible correlation with the *nicklesi* horizon of Spain and SE France. Unfortunately this form has not been found in NW Europe.

### *Karakaschiceras* and *Neohoploceras*

Both genera are well known from the Mediterranean Region. There, like *Valanginites*, *Neohoploceras* has quite a short range spanning the lower/upper Valanginian boundary, while *Karakaschiceras* is a little longer-ranging. Together with *Valanginites* they briefly invaded the NW European province too (high *hollwedensis* Zone). Forms closely comparable to European species invaded the Neuquén Basin briefly; their appearance marks the base of the *K. attenuatus* Subzone (Aguirre-Urreta & Rawson, 1997; Aguirre-Urreta 1998). The *attenuatus* Subzone has been correlated with the upper part of the *campylotoxus* Zone (*Karakaschiceras inostranzewi* Zone of

Bulot & Thieuloy, 1995) and the *verrucosum* Zone of the Mediterranean area (Aguirre-Urreta & Rawson, 1997). Rawson (1995) correlated these Mediterranean zones with the *hollwedensis* to *crassus* Zones of NW Europe (Fig. 2).

### *Neocomites*

This well-known Tethyan genus occurs also in Argentina and at one level (*Neocomites* sp. Subzone) provides a clue for correlation with the Mediterranean area, though the Argentine species are not identical to Mediterranean taxa. Rare *Neocomites* are recorded from the upper Valanginian of North Germany (Kemper et al., 1981) but again do not compare closely with Argentine forms.

### *Oosterella*

*Oosterella* is not a common genus anywhere. It is best known from the Mediterranean Region where it ranges from the mid Valanginian to the lower part of the *radiatus* Zone at the base of the Hauterivian. Two specimens are known from the Neuquen Basin (Aguirre-Urreta & Rawson, 1996) and help to constrain the age of the *Neocomites* sp./*Holcoptychites nequensis* Subzones there. Rare specimens are also recorded from the upper Valanginian of North Germany (Kemper et al., 1981) but, like *Neocomites*, do not provide evidence for correlation with Argentina.

### *Spitidiscus*

*Spitidiscus* is a long-ranging (lower Hauterivian to lower Barremian) and widely distributed genus in Tethyan areas. But in Argentina and NW Europe its occurrence is much more restricted. In Argentina forms comparable with Mediterranean *Spitidiscus* of the mid-Hauterivian *nodosoplicatum* Zone (Bulot, pers. commun.) appear in black shales at the base of the Upper Agrio Member (Aguirre-Urreta & Rawson, 1997, fig. 6c-g). In NW Europe there are two main levels — in the highest part of the *regale* Zone and in the upper part of the *speetonensis* Zone (Kemper et al., 1981). A *Spitidiscus* cf. *subcassida* from the high *regale* Zone at Speeton in eastern England (Kemper et al., 1981, pl. 34, figs. 9-10) belongs to the same group as the Argentine and *nodosoplicatum* Zone forms.

### *Crioceratites*

*Crioceratites* is another long-ranging genus (upper Valanginian to Barremian). But it 'bloomed' in the mid Hauterivian, when forms of the *nolani-duvalii* group spread rapidly over much of the world (Rawson, 1981). In both NW Europe and Argentina these forms first appeared just after the invasion of *Spitidiscus*, and examples from both areas are virtually indistinguishable from typical Mediterranean forms.

## Discussion

Not all of the genera discussed above are important for long-range correlation, and those that may be of value have to be examined critically. In particular, the short

vertical range but wide geographical distribution of *Valanginites* in Europe could suggest that the horizon of this taxon in Argentina should be correlated with a level at about the middle of the Mediterranean Valanginian. But if that were so, then what would one correlate the higher Argentine *Olcostephanus* and *Olcostephanus/Karakaschiceras/Neohoploceras* assemblages with? Conversely, if the latter are correlated with the corresponding Mediterranean assemblages, then what does the Argentine *Valanginites* fauna correlate with?

*Valanginites* may have originated in the Colombian/Central American area, where it first appeared earlier than in Europe, and had a longer time range (Aguirre-Urreta & Rawson, 1998). The Argentine records would thus represent a brief-lived invasion of an early form, while the European records would represent a later invasion. In this context, it is interesting to note that Faraoni et al. (1997, pl. 5, fig. 14) have recently figured as *Valanginites* sp. a poorly preserved ammonite from the *petransiens* Zone of the Chiaserna-Monte Catria section of the Italian Appenines. If this is a true *Valanginites* then the record could be of similar age to the Argentine forms.

Close ties between all three areas can then be made at two levels (Fig. 2). The first is in the mid Valanginian. Here, there is a close similarity in the *Olcostephanus* and neocomitid faunas. *Olcostephanus* of the *atherstoni/guebhardi* group appeared in abundance firstly in the Argentine and Mediterranean sequences, eventually spreading briefly to NW Europe. In the former sequences it was then joined by *Karakaschiceras* and *Neohoploceras*, both of which also migrated briefly to NW Europe, along with *Valanginites* and the short-lived Mediterranean zonal index *Saynoceras verrucosum* (Kemper et al., 1981, pl. 36, figs. 7-10; pl. 38, figs. 9-10).

In the mid Hauterivian there is a comparable picture. *Spitidiscus* spread from the Mediterranean area southward to Argentina and northward to NW Europe, followed almost immediately by *Crioceratites* of the *nolani/duvalii* group.

As I have previously discussed in some detail (Rawson, 1993, 1994), both levels represent intervals of significant global sea level rise. On both occasions some ammonite spread far beyond their normal areas of distribution to provide a key for long distance correlation. On other occasions, migration of Tethyan ammonites into one or other of the Argentine and NW European basins facilitated correlation between the individual basin and the Mediterranean Tethys.

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