Life in Stone

A Natural History of British Columbia's Fossils

Edited by

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11
Ammonoids: Itinerants of the Jurassic

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Ammonoids reached their heyday in the Jurassic, a system characterized by their rapid speciation, their ubiquitous presence in sedimentary strata, and their widespread geographic distribution. These features led to the use of ammonoids as precise dating tools for Jurassic sedimentary rocks. Over the last century, paleontologists in Europe have refined the ammonoid zonations that now provide the key to dating many geologic and tectonic events.

Early on, Jurassic paleontologists in North America attempted to force their faunas into European zonations. These attempts inevitably led to failure because certain key European species – and even genera – are absent in North America. In addition, until recently, few attempts were made to collect ammonoids systematically in a stratigraphic sequence. Instead, paleontologists in North America generally worked with isolated collections provided by geologists. In fact, the complexity of the Canadian Cordillera and the inaccessibility of many areas made it exceedingly difficult to collect specimens in any kind of systematic order. Recent studies in the Queen Charlotte Islands, however, have yielded excellent Lower Jurassic ammonoid faunas, which have at last provided a framework for an ammonoid zonation applicable to western North America (Smith et al. 1988).

British Columbia contains extensive exposures of Jurassic sediments. Most are located in Stikinia and Wrangellia, terranes that were accreted to ancient North America. The Lower and Middle Jurassic are the more widely exposed, and these rocks are currently undergoing sedimentologic and biostratigraphic studies. The Upper Jurassic is not as well exposed and thus is poorly understood at this time.

Ammonoids are common throughout the Jurassic, being preserved generally as flattened impressions and less commonly as three-dimensional specimens. BC paleontologists compare their specimens to those from South America, Europe, Siberia, and Arctic Canada. As a result, we know that the ammonoid faunas in British Columbia are more similar to those of South America and the Mediterranean region than to those of closer areas such as Siberia and Arctic Canada. The best examples of Jurassic ammonoids are those from the Lower Jurassic. These fossils are the focus of this chapter.

Jurassic Fossils in British Columbia

Jurassic fossils have been collected throughout British Columbia from the Rocky Mountains in the east to Vancouver Island in the west, and from Manning Park in the south to Atlin Lake in the north. An attempt to document all of these collections would require an entire volume in itself. Some of the best areas are at Harrison Lake, Tyaughton Creek, the Copper River near Smithers, and the Spatsizi Plateau north of Hazelton. The best and most prolific ammonoid faunas of the BC Jurassic are those from the Queen Charlotte Islands.

Some of the earliest geologists to explore the Queen Charlotte Islands were also among the first to collect Jurassic fossils in British Columbia. George M. Dawson collected numerous specimens, some erroneously identified as Cretaceous. These specimens gave the first indication of the extensive and well-preserved ammonoids that occur in this area. When Atholl Sutherland Brown mapped the Queen Charlotte Islands during the 1950s and 1960s, he collected additional material that confirmed the presence of almost the entire Lower and Middle Jurassic succession.

It was not until the late 1970s and 1980s, however, that systematic attempts were made to collect and describe Jurassic fossils from the Queen Charlotte Islands in paleontological rather than geological studies. Hans Frebold, the Jurassic ammonoid expert of the Geological Survey of Canada, identified most of these collections, using his extensive knowledge of northwest European ammonoids.

Key Ammonoid Players in the Lower Jurassic

Because Lower Jurassic ammonoids are best preserved in the Queen Charlotte Islands, this area is the source of most of the important breakthroughs in ammonoid biochronology and paleobiogeography. One of the easiest ammonoids to recognize in the Lower Jurassic is *Amaltheus,* a genus also common in northwest Europe (Figure 11.1). It has a crenulated keel, looking rather like a rope coiled around the outside of the shell. *Amaltheus* has been collected at several localities across northern British Columbia, the Yukon, and Arctic Canada. It occurs only in the middle part of the Lower Jurassic, where it provides direct time correlations among North America, Japan, Siberia, Greenland, and northwest Europe. Because dating rocks is one of the primary uses of fossils, easily recognizable forms are particularly useful tools for a paleontologist. To

Figure 11.1 ***Amaltheus stokesi*****, a Boreal ammonoid from the Fernie Group, northeastern British Columbia.** Actual size.
Source: Collections of the Geological Survey of Canada

the astonishment of regional geologists, a small fragment of an *Amaltheus* keel can provide a precise age, whereas relatively complete but undistinguished ammonoids usually provide only a general date.

Another example comes from slightly younger rocks of the uppermost Lower Jurassic. In the 1980s several strange and perplexing ammonoids could not be assigned to an existing species, genus, or even family. Comparisons with European and South American forms were no help. A tiny specimen from the Spatsizi area in north-central British Columbia finally provided the breakthrough. A single spine projecting from one of the nodes proved to be very similar to the genus *Leukadiella* from the Mediterranean region. *Leukadiella* is characterized by nodes and by paired ribs that curve across the flanks (Figure 11.2). A comparison of these North American specimens with European specimens of *Leukadiella* was difficult due to size differences – the European specimens are small and usually less than ten centimetres in diameter, whereas those from North America may reach twenty-five centimetres in diameter. Because the characteristic ornamentation of *Leukadiella* is easily recognizable, however, the specimens from the Hazelton and Harrison Lake areas could be identified confidently even though they were poorly preserved. These ammonoids give precise ages necessary for regional geological studies.

Occasionally paleontologists come to the conclusion that they are deal-

Figure 11.2 ***Leukadiella ionica,*** **a Tethyan ammonoid from the Maude Group, Queen Charlotte Islands.** Actual size.
Source: Collections of the Geological Survey of Canada

ing with a new species or new genus. The uppermost Lower Jurassic in the Queen Charlotte Islands provided such a case. The upper part of the Whiteaves Formation in the Queen Charlotte Islands contains numerous discoidal calcareous concretions that become exposed as weathering erodes the surrounding soft shales. Along one section, the concretions tend to weather out of the shale slope and accumulate along the river bank where constant immersion in water makes them easy to crack open. These concretions have yielded some of the best-preserved Lower Jurassic ammonoids in North America. One of the more common ammonoids collected here is *Phymatoceras hillebrandti,* a newly described species that is related to a South American form (Figure 11.3). This species also appears to be the ancestor of a new genus that occurs in the overlying Phantom Creek Formation of the Queen Charlotte Islands.

The Phantom Creek Formation is a shallow-water sandstone that contains large calcareous concretions greater than one metre long. Some of these concretions are packed with beautifully preserved three-dimensional ammonoids and bivalves. Regular hammers and chisels are not up to the task – it is only with the aid of a sledgehammer that these blocks are broken into manageable pieces. Several genera and species were identified in these concretions but several other forms were not so easily pigeonholed.

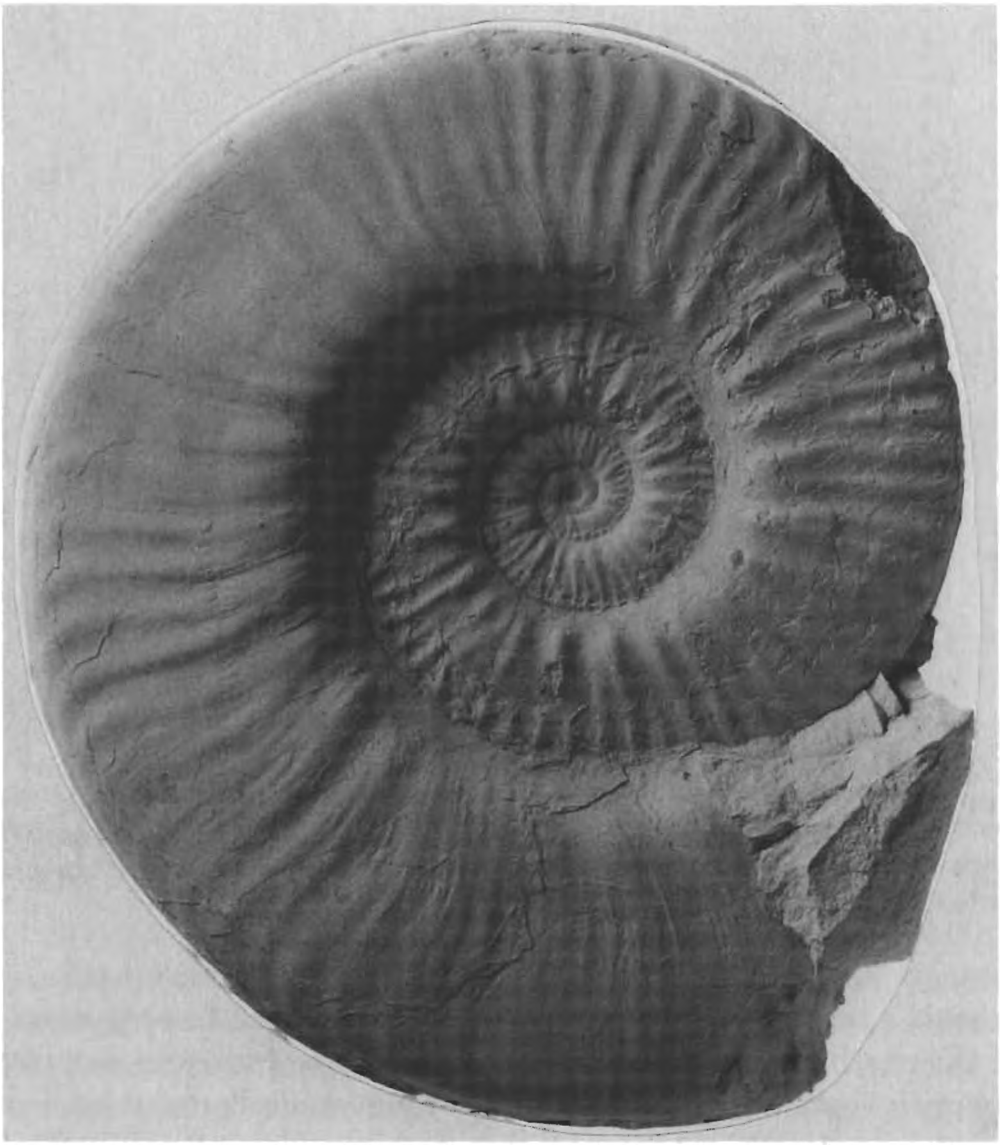

Figure 11.3 **Phymatoceras hillebrandti, a common ammonoid from the Whiteaves Formation, Queen Charlotte Islands.** Actual size.
Source: Collections of the Geological Survey of Canada

Comparison of these ammonoids with those previously described suggested that the only other similar forms occurred in the Rocky Mountains and Alaska and that these forms had been equally difficult to correlate with known genera. In the end, a new genus was established – *Yakounia* includes four species, each occurring only in North America (Figure 11.4). Also occurring was *Pleydellia maudensis,* a new species that differs from other species of *Pleydellia* by the prominent umbilical tubercles present at later stages of growth (Figure 11.5).

Paleontologists are intrigued by the similarities and differences in ammonoid faunas that occur on different continents and within areas on one continent. Interest in this subject has led to a separate field of study called paleobiogeography.

Figure 11.4 ***Yakounia freboldi,*** **a common ammonoid from the Maude Group, Queen Charlotte Islands.** Actual size.
Source: Collections of the Geological Survey of Canada

Figure 11.5 ***Pleydellia maudensis,*** **a well-preserved ammonoid from the Phantom Creek Formation, Queen Charlotte Islands.** Actual size.
Source: Collections of the Geological Survey of Canada

Jurassic Paleobiogeography

Biogeography is the study of the geographic distribution of organisms. Biogeographers today are trying to determine why certain species occur only on one continent, or in one ocean, and not another. Are there geographic or climatic barriers that prevent migration?

Organisms that are distributed globally are referred to as pandemic. Endemic organisms, on the other hand, are confined to certain areas, possibly due to geographic or climatic barriers. A modern-day example is the penguin, which is endemic to the southern polar region, or the kangaroo, which is endemic to Australia. An area that contains several endemic organisms is distinguished from other regions and is called a province (Smith 1989).

The distribution of terrestrial and freshwater organisms is influenced by barriers such as climate, mountain ranges, deserts, and oceans. Thus this distribution shows strong endemism. Shallow-water, bottom-living (benthic) marine organisms such as bivalves, gastropods, and echinoids (for example, sea urchins and sand dollars) also tend to show strong endemism due, in part, to their inability to cross deep ocean basins. In contrast, floating (pelagic) and swimming (nektic) marine organisms such as fishes, squid, and whales tend to have a pandemic distribution, although climate can also affect their distribution.

Paleobiogeography is the study of the geographic distribution of ancient organisms. Paleontologists studying the paleobiogeographic distribution of fossils in the Jurassic need to consider several factors. First and foremost is the location of the Jurassic continents. During the Early Jurassic the present continents were grouped together to form one large supercontinent, Pangaea (Figure 11.6). The ancestral Atlantic Ocean was in its initial stages of rifting and the ancestral Pacific Ocean (Panthalassa) was over 10,000 kilometres wide. Europe and Asia were separated from Africa, Arabia, India, and Australia by the wedge-shaped and tropical Tethyan Ocean, of which the present-day Mediterranean is the only remnant. A second factor that must be considered is the climate. The Jurassic was considerably warmer than the present. Paleontological and geological evidence suggests that polar ice caps were non-existent during the Jurassic. The difference between temperatures at the poles and those at the equator was smaller than it is today, resulting in a more equitable global climate.

It is logical to expect Jurassic ammonoids, with their pelagic mode of life, to have a pandemic distribution with little provincialism. As early as the late 1800s, however, paleontologists in Europe documented variations in the distribution of ammonoids that clearly identify distinct realms. The Boreal Realm includes northern high-latitude ammonoids such as *Amaltheus,* whereas the Tethyan Realm encompasses low-latitude

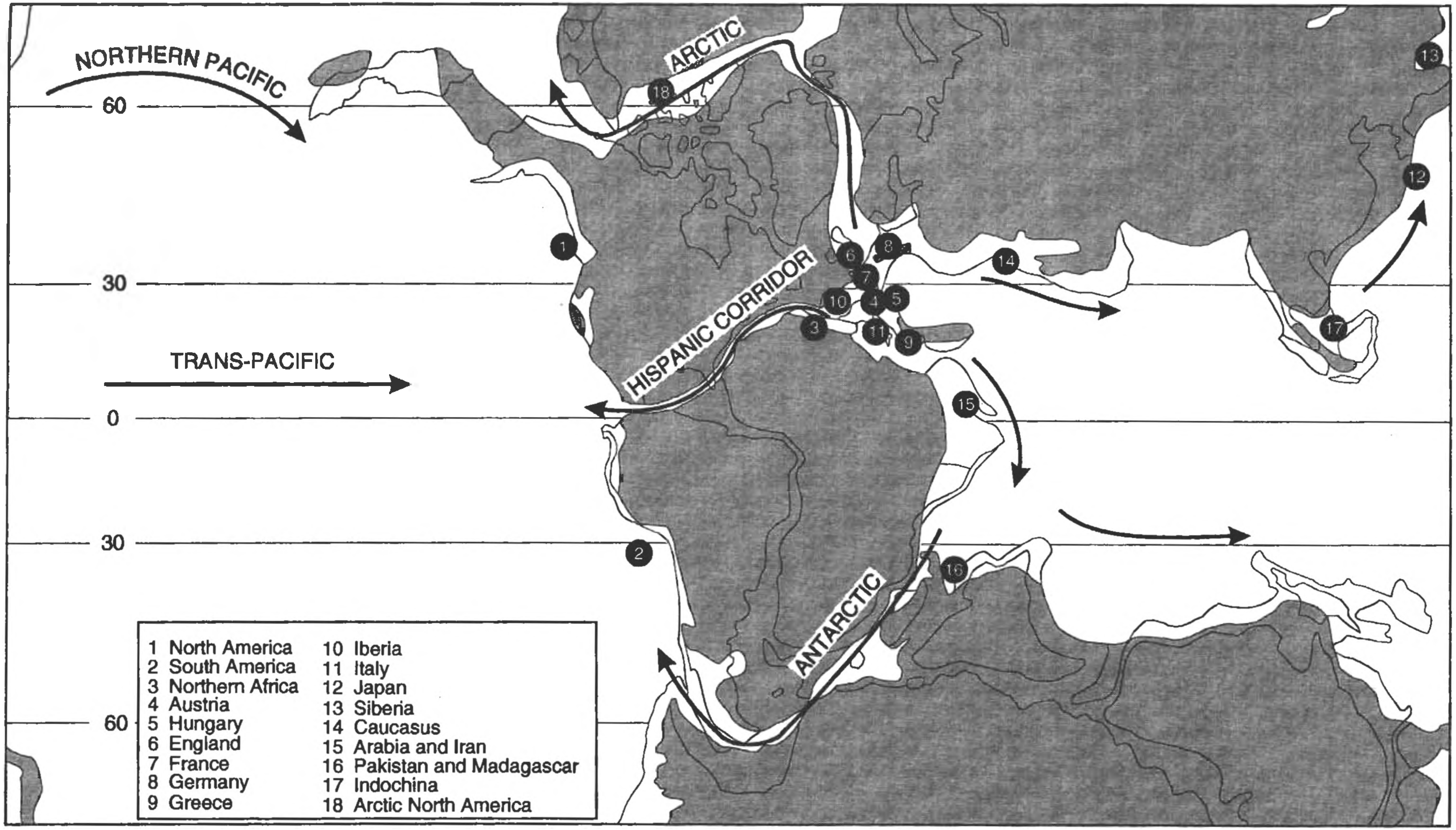

Figure 11.6 **The supercontinent Pangaea during the Early Jurassic.** Possible migration routes of ammonoids from the western part of the Tethyan Ocean to the eastern part of the ancient Pacific Ocean are indicated by arrows.

equatorial forms such as *Leukadiella.* An Austral Realm comprises southern high latitudes, but it was not well developed in the Jurassic. Generally the boundaries between the realms are transitional, their position shifting over time.

In 1967 a revolutionary paper was published on the geographic distribution of Lower Jurassic ammonoids in Europe. D.T. Donovan, a British paleontologist, reported that the majority of genera were pandemic, occurring from Britain in the north to Morocco and Algeria in the south. He had also discovered that, at certain times in the Early Jurassic, a significant proportion of the genera were either northern or southern in their distribution. This distinction was particularly noticeable in the late part of the Early Jurassic when there were relatively few pandemic genera but many Tethyan or Boreal genera. An apt illustration is the distribution of ammonoid families – the Tethyan Hildoceratidae and the Boreal Amaltheidae (Figure 11.7). The southern and northern limits of the hildoceratids and amaltheids are aligned roughly east-west, suggesting that climate probably played a role in these distributions.

At one time, temperature variation across latitudes was a common explanation for the dispersal of ammonoids and other marine animals during the Jurassic. Paleontologists thought that the Jurassic may have been similar to the present, with high-diversity faunas distributed along the equator and low-diversity faunas located at the poles. As mentioned earlier, however, evidence suggests that the Jurassic climate was more equitable than at present. As well, the absence of a south polar Austral Realm during the Jurassic suggests that polar-equatorial temperature differences did not play a large role in the geographic distribution of marine organisms.

Other paleontologists postulated that variations in salt content, or salinity, existed between the northern seas and the low-latitude equatorial belt during the Jurassic. They suggested that the northern seas in Europe, bounded on almost all sides by land masses, may have had slightly lower salinities than normal marine waters. If that were the case, however, ammonoids, brachiopods, bivalves, and echinoids could not have existed there.

Recent studies suggest that one of the key factors controlling diversity in modern oceans is environmental stability. Unstable environments such as nearshore areas and estuaries are subject to rapid changes in temperature and salinity, and tend to have low diversity in animal life. Stable environments, which are generally offshore, experience less change in temperature, salinity, and food supply, and are populated by diverse assemblages of organisms. During the Jurassic, the environment of the Boreal seas was probably unstable due to salinity fluctuations caused by the influx of fresh water off the continents and to a strong seasonal

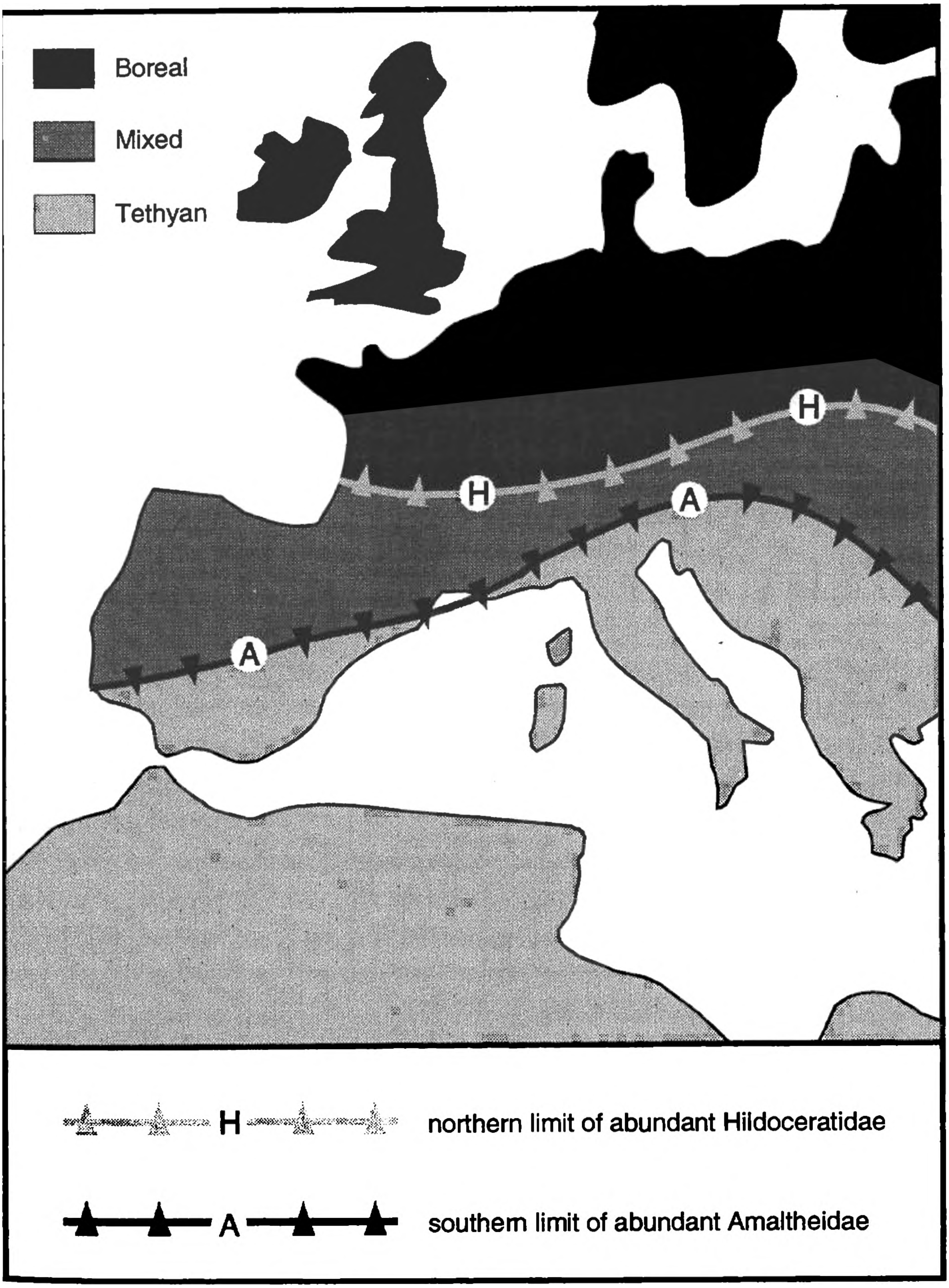

Figure 11.7 **Boreal and Tethyan realms in Lower Jurassic strata of Europe, as defined by abundance patterns of two ammonoid families**
Source: From Donovan (1967)

contrast in temperature and light. These factors were probably intensified by the shallowness of the northern seas. The likely result is that Boreal faunas living in these unstable environments exhibited lower diversity than Tethyan faunas living in stable environments.

Paleobiogeography of British Columbia

BC paleontologists have used Jurassic ammonoid paleobiogeography to determine the extent of movement of the Cordilleran terranes and to define the probable ammonoid migration routes between the Tethys Ocean and the eastern Pacific Ocean.

Terranes

The main focus of recent work on Lower Jurassic ammonoids of British Columbia has been to determine whether the difference in diversity between the Tethyan and Boreal realms in Europe can be recognized in North America (Smith and Tipper 1986). Unlike Europe, British Columbia is a collage of transported terranes, which joined ancestral North America during the Jurassic and Cretaceous (Yorath 1990). Geological evidence suggests that during the Early Jurassic, these terranes were much farther south and at different relative latitudinal positions. Each must be analyzed separately when studying the biogeography of the province, and then compared to the neighbouring terranes and to the craton, that is, the large, stable nucleus of the continent.

The North American craton shows a faunal distribution pattern similar to that of Europe. Low-diversity Boreal faunas occur in the Canadian Arctic and northern Alaska and as far south as Alberta, whereas high-diversity Tethyan faunas are found in Nevada. The terranes Quesnellia and Stikinia have Tethyan faunas in their southern parts and mixed faunas in the northern parts. Wrangellia, a fragmented terrane now located in southern Alaska, the Queen Charlottes, Vancouver Island, and Oregon, shows a similar pattern, with Tethyan faunas in the southern part and mixed faunas to the north (Figure 11.8A).

By comparing the faunas of the transported terranes with those on the craton, paleontologists can reconstruct the probable position of the terranes with respect to the craton and to each other (Smith and Tipper 1986). Thus we know that, during the later part of the Early Jurassic, Wrangellia, Stikinia, and Quesnellia were located at lower latitudes than they are today, approximately at the latitude of Nevada (Figure 11.8B).

Migration Routes

Four migration routes have been proposed to explain the strong similarity between ammonoid faunas of the eastern Pacific and those of the western Tethys during the Early Jurassic (Figure 11.6). An Arctic migration pathway via Great Britain, Spitsbergen, and the North American Arctic is thought to have been open in the Early Jurassic. A southern migration route via eastern Africa and the Antarctic has also been proposed, as has eastward migration along the southern and northern margins of Tethys or dispersal across the ancestral Pacific Ocean. In addition, several paleontologists have postulated the presence of an Hispanic Corridor, a narrow seaway linking the Pacific with western Tethys along the newly opened North Atlantic. Each of these possibilities merits discussion.

Geological and paleontological evidence from northern Europe, Greenland, Spitsbergen, and Arctic Canada suggests that an Arctic migration route persisted throughout the Jurassic as a shallow seaway. This migration route probably helped the spread of Boreal ammonoids such as *Amaltheus* across the Arctic and down the coastline of ancestral North America. This high-latitude route was not feasible for Tethyan ammonoids, however, which were confined to low latitudes.

A southern migration route via eastern Africa and Antarctica is unlikely, since no marine Jurassic rock is known in Africa south of Tanzania. In addition, the Early Jurassic ammonoids of eastern Africa and Arabia are of low diversity and quite different from the high-diversity faunas of southern Europe, North America, and South America. If migration had occurred along this route, we would expect to find a strong similarity among the faunas of these regions. The absence of characteristic Tethyan genera from Africa and Arabia suggests that, if this route was open during the Early Jurassic, it probably was a very shallow seaway of low environmental stability that acted as a barrier to the migration of Tethyan ammonoids.

Eastward migration of Tethyan forms along the southern coastline of Tethys has been suggested, but there is little evidence for this route. Ammonoid collections of late Early Jurassic age from Saudi Arabia, Iran, and Pakistan have very low diversities and lack the distinctive Tethyan elements. Lower Jurassic deposits in Australia and New Zealand have yielded only very few ammonoids, and these are quite different from the high-diversity Tethyan faunas.

Migration eastward via the northern margin of Tethys and the northern Pacific has also been suggested as a means of faunal exchange. If migration had occurred along this route, we would expect to find examples of Tethyan ammonoids in the Caucasus, Indonesia, and Japan. Instead, these areas contain pandemic or Boreal genera but no low-latitude Tethyan genera.

Several paleontologists have suggested that westward migration of marine faunas between the western Tethys and the eastern Pacific occurred along an Hispanic Corridor, a shallow seaway across what are now Central America and the Caribbean (Figure 11.6). Evidence from a variety of fossil groups supports this model, suggesting that this corridor was open from the Early Jurassic on. In addition, numerous Lower Jurassic ammonoid genera such as *Leukadiella* occur only in the western Tethys and the eastern Pacific, suggesting a direct marine connection between

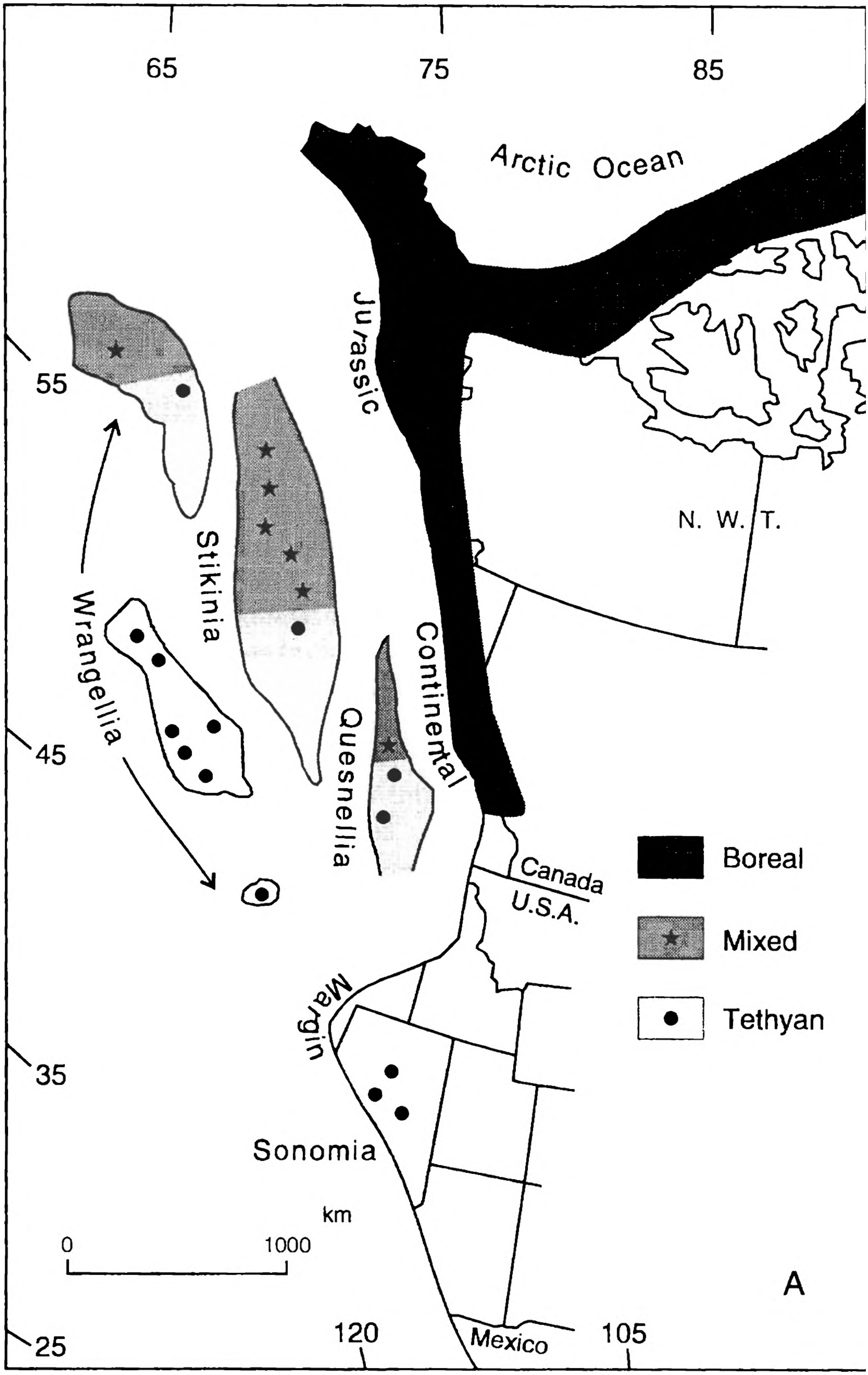

Figure 11.8 **Paleobiogeography and Cordilleran terranes.** (A) Early Jurassic biogeographic realms and transported terranes (shown pulled off the continent).

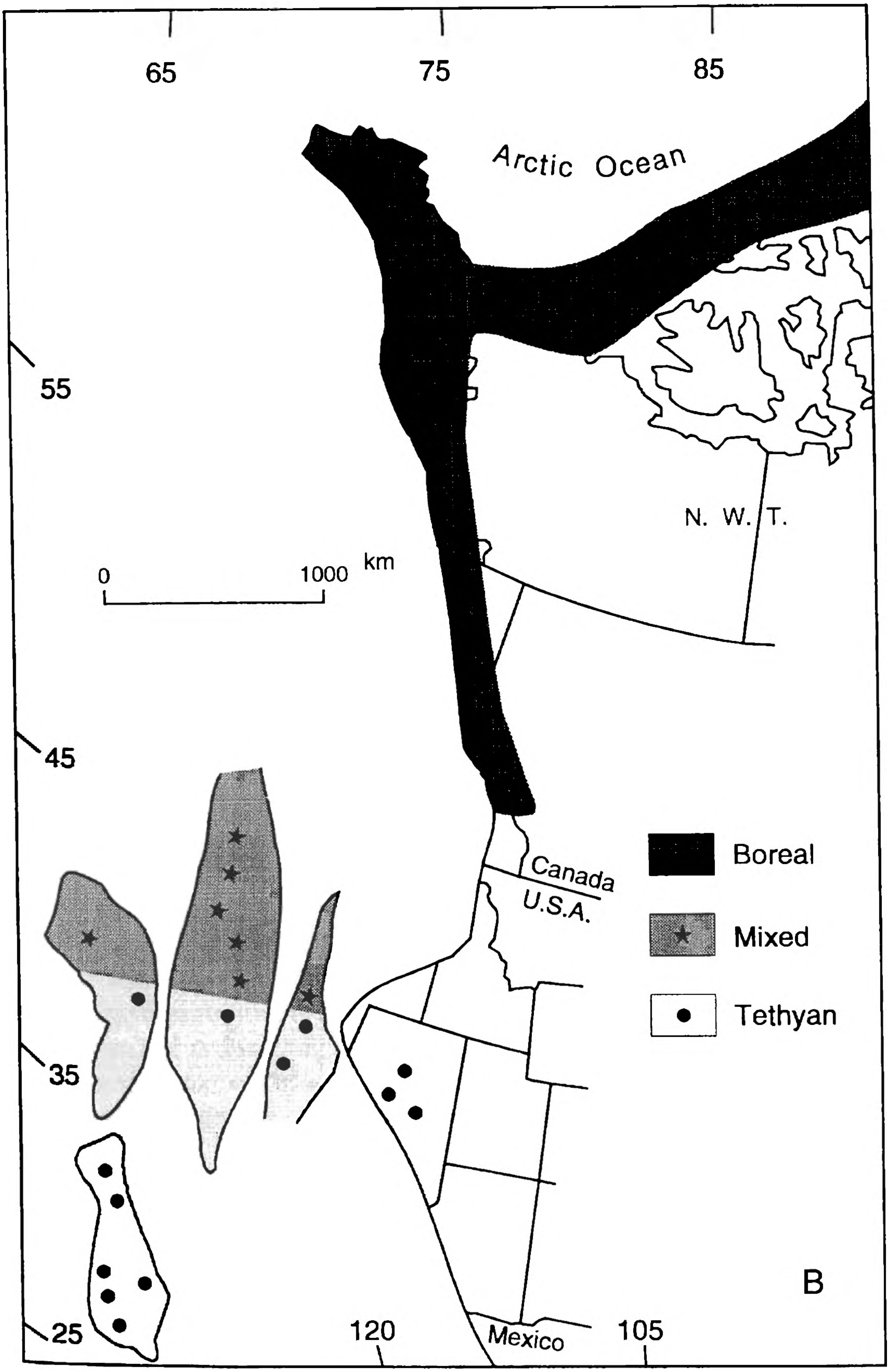

Figure 11.8 [Continued]. (B) Possible location of terranes during the Early Jurassic based on biogeographic assignments. No longitudinal position of the terranes is implied.
Source: From Smith and Tipper (1986)

the two areas. Statistical analyses of the global distribution of Lower Jurassic genera suggest that migration of certain Tethyan forms was directly controlled by sea level. Accordingly, it is probable that a rise in the sea level at that time allowed the migration of low-latitude forms between the eastern Pacific and western Tethys along the Hispanic Corridor.

Lower Jurassic ammonoids from British Columbia are an invaluable dating tool for geologists and paleontologists. These fossils have assisted in unravelling the complicated geologic history of the Canadian Cordillera. In addition, they have improved our understanding of geography during the Jurassic when the ancient supercontinent Pangaea was beginning to fragment.

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