Marine Triassic Faunas of North America: Their Significance for Assessing Plate and Terrane Movements

By E. T. TOZER, Ottawa *)

With 2 figures and 2 tables

Zusammenfassung

Die Verbreitung der marinen Invertebratenfaunen der Trias Nordamerikas wird im Hinblick auf Aussagen zur Paläolatitude durchgesehen.

Marine Trias gibt es auf der Nordamerikanischen Platte über 46 Breitengrade von Californien bis nach Ellesmere Island. Für einige Zeitabschnitte lassen sich zwei bis drei unterschiedliche Faunenprovinzen gegeneinander abgrenzen. Die Unterschiede in den Faunen sind offensichtlich an die Paläolatitude geknüpft. Sie werden als LPL, MPL, HPL (niedere, mittlere, höhere Paläolatitude) bezeichnet. Nevada liefert die diagnostischen Merkmale der niederen; das nordöstlich British Columbia die der mittleren und das Sverdrup Becken die der höheren Paläolatitude. Eine Unterscheidung zwischen den Provinzen der mittleren und der höheren Paläolatituden läßt sich für die Untertrias und tiefere Mitteltrias (Anis) nicht treffen. Jedoch lassen sich in den Ablagerungen des Ladin, Karn und Nor alle drei Provinzen erkennen.

In den westlichen Zügen der Cordilleren sind marine Faunen vom südlichen Alaska und Yukon bis nach Mexico aus den bezüglich der Nordamerikanischen Platten offensichtlich allochthonen Teilen bekannt. Unter- und obertriadische Faunen dieser Gebiete so wie einige, die heute bis 63° Nord liegen besitzen die Charakterzüge der niederen Paläobreiten. Mitteltriadische Faunen dieser Zonen liefern, soweit bekannt, keine wesentlichen Daten. In den westlichen Cordilleren finden sich die Faunen der niederen Paläobreiten bis zu 3000 km nördlich ihrer Gegenstücke auf der Amerikanischen Platte. Damit wird eine tektonische Verschiebung dieser Größenordnung angezeigt.

Betrachtet man die Faunen und die Art der Sedimente, dann läßt sich die Paläogeographie der Trias wie folgt interpretieren: eine tektonisch ruhige Westküste der Nordamerikanischen Platte, die an ein offenes Meer grenzte; im küstenferneren Gebiet lieferte eine Serie vulkanischer Archipele Sediment in die angrenzenden Becken. Einige waren gesäumt oder zeitweise bedeckt von korallenführenden Watten und Karbonatbanken. Tiefere Becken lagen dazwischen. Die Inseln lagen wahrscheinlich innerhalb 30° nahe dem triadischen Äquator. Sie zogen sich von der Küste weg bis etwa 5000 km Entfernung zum Vorläufer des Ostpazifischen Rückens. Die geographische Situation westlich des Rückens sah vermutlich ähnlich aus.

Jurassische und spätere Generationen der Kruste aus der Nähe des Rückens haben einige der Inseln in die Nordamerikanische Platte eingebracht; einige wahrscheinlich nach Südamerika; andere sind nach Westen, nach Asien gedriftet. Es gibt Anzeichen dafür, daß Neuguinea, Neukaledonien und Neuseeland zur Triaszeit auf einer nördlichen Breite von 30° oder mehr gelegen haben.

Die Züge, die heute die westlichen Cordilleren bilden, waren wahrscheinlich zusammengeschweißt und haben die Nordamerikanische Platte vor Ende der Jurazeit erreicht.

Abstract

The distribution of marine Triassic invertebrate faunas in North America is reviewed to recognize forms that may have paleolatitudinal significance.

*) Address of the author: E. T. TOZER, Geological Survey of Canada, Department of Energy, Mines and Resources, Ottawa, Ontario, K1A OE8, Canada.

Marine Triassic occurs on the North American Plate over a latitudinal spread of 46 degrees, from California to Ellesmere Island. At some intervals of time faunas on the Plate permit the discrimination of two or three provinces with distinctively different coeval faunas. The faunal differences are evidently related to paleolatitude and the provinces are designated LPL, MPL, HPL (low, mid, high paleolatitude). Nevada provides the diagnostic characters of the LPL province; northeastern British Columbia the MPL; the Sverdrup Basin the HPL. In the Lower Triassic and early Middle Triassic (Anisian) the distinction between the MPL and HPL provinces cannot be made. All three provinces are recognized in the Ladinian, Carnian and Norian deposits.

In the western tracts of the Cordillera, the part formed of suspect terranes, apparently allochthonous with respect to the North American Plate, marine faunas are known all the way from southern Alaska and Yukon to Mexico. Lower and Upper Triassic faunas from these terranes, including some which today are at 63 degrees north, have the characters of the LPL province. Middle Triassic faunas from the terranes, as presently known, do not contribute significant data. In the terranes of the Western Cordillera LPL faunas are now up to 3000 km north of their counterparts on the American Plate. Tectonic displacement of this order is indicated.

Taking into account the faunas and the nature of the rocks, the Triassic palaeogeography is interpreted as: a tectonically quiet west shore for the North American Plate, bordered by an open sea or ocean; then, well off-shore, a series of volcanic archipelagos shedding sediment into adjacent basins. Some were fringed or intermittently covered by coralline shoals and carbonate banks. Deeper basins were in between. The islands probably were within 30 degrees of the Triassic equator and extended offshore for about 5000 km, to the spreading ridge directly ancestral to the East Pacific Rise. The geography west of the spreading ridge was probably comparable.

Jurassic and later generation of crust at the ridge has driven some of the islands into the North American Plate; some probably to South America; others have gone west to Asia. Evidence is given that northern New Guinea, New Caledonia and New Zealand may have been at a north latitude of 30 degrees or more in the Triassic.

The terranes now forming the Western Cordillera had probably amalgamated, and reached the North American Plate, before the end of the Jurassic.

Résumé

La distribution des faunes d'invertébrés marins du Triasique dans l'Amérique du Nord est passée en revue afin de reconnaître les formes qui peuvent avoir une signification pour les latitudes du passé.

Le Triasique marin existe sur la plaque de l'Amérique du Nord sur 46, degré de latitude, de la Californie à l'Ile d'Ellesmere. A certains intervalles de temps, des faunes permettent la distinction de 2 ou 3 provinces à partir de faunes contemporaines nettement différentes. Les différences de faunes se montrent en relation évidente avec la paléolatitude, et les provinces sont désignées LPL, MPL, HPL (base, moyenne, haute paléolatitude). Le Nevada fournit la diagnose de la province LPL; le NE de la Colombie britanique, le MPL; le bassin de Sverdrup, le HPL. Dans le Triasique inférieur et le début du Triasique moyen (Anisian), la distinction ne peut être faite entre provinces MPL et HPL. Les 3 provinces sont chacune reconnues au Ladinien, au Carnien ent au Norien.

Dans les aires occidentales de la Cordillère, dans la partie formée de terrains apparemment allochtones par rapport à la plaque de l'Amérique du Nord, des faunes marines sont connues depuis l'Alaska méridional et le Yukon jusqu'au Mexique. Des faunes du Trias inférieur et Supérieur de ces terrains, y compris certaines qui aujourd'hui se trouvent à 63° N, ont les caractères de la province LPL. Des faunes du Triasique moyen de ces terrains, à présent connues, n'apportent pas de données significatives. Dans les terrains de la Cordillère occidentale, des faunes LPL sont connues actuellement jusqu'à 3000 km. au nord de leurs correspondants sur la plaque américaine, indiquant un déplacement tectoniue de cet ordre.

Prenant en considération les faunes et la nature des roches, la paléogeographie du Triasique est interprétée comme suit: un rivage occidental tectoniquement calme pour la plaque de l'Amérique du Nord, bordée par une mer ouverte ou un océan; ensuite, à l'écart de ce rivage, une série d'archipels volcaniques distribuant des sédiments dans les bassins adjacents. Les îles étaient probablement dans un espace de 30° à partir de l'équateur triasique, et s'étendaient au delà du rivage sur environ 5000 km. jusqu'à la ride d'expansion qui fut l'ancêtre direct de l'East Pacific Rise. La géographie à l'ouest de la ride d'expansion était probablement comparable.

La croûte engendrée au Jurassique et plus tard à partir de cette ride a entraîné certaines de ces iles volcaniques dans la plaque de l'Amérique du Nord; certaines probablement jusqu'à l'Amérique du Sud; d'autres s'en sont allées vers l'ouest vers l'Asie. Des faits montrent que le Nord de la Nouvelle Guinée, la Nouvelle Calédonie et la Nouvelle Zélande peuvent s'être trouvées à une latitude nord de 30° et plus au Triasique.

Les terrains formant actuellement l'ouest de la Cordillère s'étaient probablement réunis et avaient atteint la plaque de l'Amérique du Nord avant la fin du Jurassique.

Краткое содержание

Рассмотрено распостранение морских беспозвоночных в различных палеоширотах северной Америки в триасе.

Морские отложения триаса на североамериканской платформе простираются на более, чем 46 широтных градуса от Калифорнии до островов моря Эллис. для некоторых отрезков времени можно разграничить от двух до трех различных провинций фауны. Различия в фауне явно связаны с палеоширотой. Их именуют низкие, средние и высокие палеошироты (LPL, MPL, HPL). В Неваде находят отличительные признаки низких широт; северовосточная британская Колумбия относится к средним, а бассейн Свердрупа — к высоким палеоширотам. Различия между провинциями средних и вы с оких палеоширот и нижнем триаса и среднем триаса (анисийский век) не установлено. Зато в отложениях ладинского, карнского и новийского веков отм е чены все три провинции.

Морская фауна, известная в Кордильерах от южной Аляски и Юкона до Мексики, в основном аллохтонового происхождения. Фауна верхного и нижнего триаса этих регионов, как и некоторые районы, расположенные сегодня до 63° северной широты, несут черты фауны низких палеоширот. Среднетриасовая фауна этих зон не дает, поскольку известно, никаких важных разультатов. В западных Кордильерах находят фауну низких палеоширот до 3000 км севернее ее эквивалента на африканской платформе. Это указывает на тектоническое смещение такого же порядка.

Рассматривая фауну и тип осадочных пород можно интерпретировать палеогеографию триаса следующим образом: тектонически спокойное западное побережье североамериканской плиты, прилегающее к открытому морю; В областях, отдаленных от берега серия вулканических архипелагов поставляет седименты в прилегающие бассейны. Некоторые из них обрамляются прибрежной отмелью, или даже становятся ею, покрыпаемой водой во время приливов, заливаемой. Между ними находятся глубокие бассейны. Острова распалались, вероятно, от 30° широты, ближе к триасовому экватору. Они простираются от берега до примерно 5000 км к предшевственнику восточной части хребта Тихого океана. Географические соотношения западнее от хребта выглядели, вероятно, также, как и в восточной части.

Юрские и поздние поколения коры из районов вблизи хребта образовали острова севроамериканской плиты. Некоторые из них дрейфовали, вероятно,

к южной Америке, другие на запад, к Азии. Есть основания предполагать, что новая Гвинея, Новая Каледония и Новая Зеландия в Триасовый период располагалась на 30° северной широты, или даже выше.

Внешний вид сегодняшних западных Кордильер североамериканской платформы возник, вероятно, в конце юры.

Introduction

For some time it has been recognized that the distribution of marine Triassic faunas in North America reveals anomalies which have been interpreted to indicate substantial northward tectonic displacement in the western part of the Cordillera (TOZER, 1970, p. 653; NICHOLS and SILBERLING, 1979). Anomalies have also been recognized for the Permian (MONGER and ROSS, 1971; DANNER, 1976; YANCEY, 1979) and Jurassic (TIPPER, 1981). This paper pursues the subject and provides interpretations of faunas that contribute to understanding Triassic paleogeography and the subsequent tectonic history. Although the paper is concerned primarily with North America comparisons are also made with faunas from other parts of the world. This leads to a global review of Triassic paleogeography.

The time seems right for a new look at Triassic paleogeography for two reasons. First, the remarkably close similarities between some cephalopod and bivalve faunas of western North America with those of the western Pacific and Tethys is hard to reconcile with a conventional Triassic paleogeography with one hemisphere mostly land (Pangaea), the other wholly water (Panthalassa). A second reason for reviewing the paleogeographic significance of Triassic faunas is to examine their bearing on current tectonic interpretations in which much of the North America Cordillera is taken to be a mosaic of terranes which "seem to have been swept from far reaches of the Pacific Ocean before collision and accretion into the Cordilleran margin mostly in Mesozoic to early Cenozoic time" (CONEY et al., 1980, p. 329). Coney et al. use the term "suspect" for these terranes to emphasise the uncertainty of their original position. Now that it is known that the present ocean basins are floored with crust generated since Triassic time, as strips now cumulatively thousands of km wide, it is clear that rock formed in the Triassic may have been pushed aside for distances of the same order of magnitude. This means that paleogeographic interpretations must take into account the possibility that terranes and plates with Triassic rocks, although now closely juxtaposed, may have been separated by thousands of kilometres when they formed. This paper examines the constraints imposed by the nature of the faunas for determining the original position of the terranes.

Having recognized the possibility that extensive movements may have taken place a fundamental distinction must be made between two kinds of Triassic rock: plate-bound and suspect. Plate-bound refers to rock that was deposited on tectonic plates which have not experienced appreciable internal movement since Triassic time. Suspect is the Triassic of terranes which may have moved extensively in relation to other terranes and to the plates. The extent of the two kinds in North America is indicated on Figure 1. A sketch for the whole globe is given on Figure 2.

This paper is mostly concerned with comparing the plate-bound and suspect faunas. It will be shown that faunas evidently indicating deposition at low, mid and high paleolatitude (LPL, MPL, HPL) can be recognized on the North American plate. Comparisons will be made to estimate where the suspect terranes may have been in the Triassic. The data are interpreted to indicate that most or all of the terranes were far to the south (3000 ± 1500 km), in relation to the plate, as a belt of shoals, islands etc. some 5000 km wide. The geography of western Panthalassa was probably comparable. Some terranes now in the southern hemisphere (e. g. northern New Guinea and New Zealand) were probably north of the Triassic equator. In the resultant paleogeography the Pangaea hemisphere is balanced by one watery, but liberally strewn with islands from coast to coast (Figure 2).

Plate-Bound and Suspect Triassic: Comparisons and Boundaries

Generally the distinction between plate-bound and suspect Triassic in North America is easily made but in British Columbia and Nevada there are problems concerning the recognition of the edge of the plate (Figure 1).

Orderly stratigraphy, cratonic source of sediment and absence of volcanic rock characterize the plate-bound sequences. In East Greenland the rocks are in narrow troughs, mostly grabens (STAUBER, 1942; TRÜMPY, 1961). The Sverdrup Basin preserves a section at least 6000 m thick at the depocentre but at the margins the beds are much thinner (THORSTEINSSON and TOZER, 1970, p. 577). In Triassic time the Sverdrup Basin probably played a role like that of the Mississippi delta today (TOZER and THORSTEINSSON, 1964, p. 217). The plate-bound Triassic of the Cordillera and adjacent plains is a miogeoclinal sequence. In Canada a thickness of about 1000 m is attained. In the westernmost part of the belt, typified by sections at St. Lawrence Island (Locality 34) PATTON and DUTRO, 1970, p. D 141) and at Chert Mountain, Yukon (Locality 36) (TEMPELMAN-KLUIT, 1970, p. 12; TOZER, 1967, p. 84) the sections are remarkably thin, nearly the whole Triassic being represented by about 100 m of fine-grained sediments. These sections are taken to be the seaward thin edge of the miogeoclinal prism. They give no indication of a nearby tectonic or volcanic belt. They suggest that the western shore of Pangaea was tectonically peaceful, with no volcanoes in sight.

The Triassic of the suspect terranes is wholly unlike that of the plate. Many terranes, each with distinctively different characters, have now been distinguished. More than 20 with marine Triassic rocks have been recognized by JONES and SILBERLING (1979), CONEY et al. (1980), and MONGER et al. (1982). The sequences have one characteristic in common which immediately distinguishes them from those of the plate, namely the presence of volcanic rocks, frequently in vast amounts.

Suspect terranes with Triassic rocks are of two main kinds.

First there are terranes of mostly pelitic rocks with volcanics and chert. Permian limestone, much of it probably olistrostromal, may be associated. The Cache Creek Group of British Columbia typifies this kind of terrane (MONGER and PRICE, 1979, p. 782). The Innoko terrane of Alaska (JONES and SILBERLING, 1979) and the Roche Harbour and Eagle Cove terranes in Juan de Fuca Strait (WHETTEN et al., 1978) may be comparable. Localities are on Figure 1. The rocks of the Cache Creek Group have been compared with the ophiolitic assemblages of the Mediterranean (SOUTHER, 1977, p. 5). In this kind of terrane Triassic and Paleozoic rocks are not readily separated, indeed until recently it was believed that the

Cache Creek Group is wholly Paleozoic. The presence of Lower, Middle and Upper Triassic rocks in the Cache Creek and Bridge River groups has now been established by the discovery of conodonts and radiolarians (CAMERON and MONGER, 1971; OKULITCH and CAMERON, 1976; TRAVERS, 1978; WARDLAW and JONES, 1980; RAFEK in Trettin, 1980; ORCHARD, 1981). HALOBIA has been recorded from the Cache Creek at one locality (TRAVERS, 1978, p. 102) but recognizable Triassic megafossils are generally absent. At present it appears to be impossible to make paleozoogeographic interpretations from the microfaunas. Consequently the faunas from these terranes do not contribute to the present study. Many workers have suggested that these rocks formed in deep water and for this reason they are called the oceanic facies (Figure 1). The near or complete absence of calcareous macrofossils probably indicates deposition below the carbonate compensation depth.

The second main kind of terrane includes those with rocks that preserve relatively shallow water faunas including spongiomorphs, corals, brachiopods, mol-

---

Fig. 1. Principal localities for marine Triassic faunas. Patterned areas enclose the numerous occurrences on what in Triassic time was part of the American plate. Areas where faunas diagnostic of the LPL, MPL and HPL provinces are found are shown. Most or all faunas in the undifferentiated area between the LPL and MPL provinces are Lower Triassic and not diagnostic. Most north of 60 N have HPL faunas. K/F, Kaltag fault. T/F, Tintina fault. NRMT/F, Northern Rocky Mountain trench fault. The numerous dextral faults (Pinchi, Yalakom, Denali etc.) in the mosaic of suspect terranes are not shown.

British Columbia border zone (1—6)
1. McDame area
2. Eastern McConnell Creek area
3. Pinchi fault zone, Fort Fraser area
4. Bowron River, Prince George area
5. Woodpecker Island, Prince George area
6. Slocan Group, Lardeau area

Suspect terranes of oceanic facies (7—12)
7. Innoko terrane
8. Pingston terrane
9, 10 Cache Creek terrane
11. Bridge River terrane
12. Roche Harbour and Eagle Cove terranes

Quesnelia terrane (13, 14)
13. Nicola area
14. Kelly Hill, Washington

Stikinia terrane (15—17)
15. Lewes River
16. King Salmon Mountain
17. Snipakker Mountain
18. Tyaughton Creek (terrane uncertain)

Luning sequence
19. Pilot Mountains

Chulitna terranes
20. Upper Chulitna district

Alexander terrane (21—23)
21. Carmine Mountain
22. Keku Islets
23. Gravina Island

Wrangellia terrane (24—27)
24. Wrangell Mountains
25. Queen Charlotte Islands
26. Vancouver Island
27. Wallowa Mountains

Central Oregon
28. Suplee-Izee area

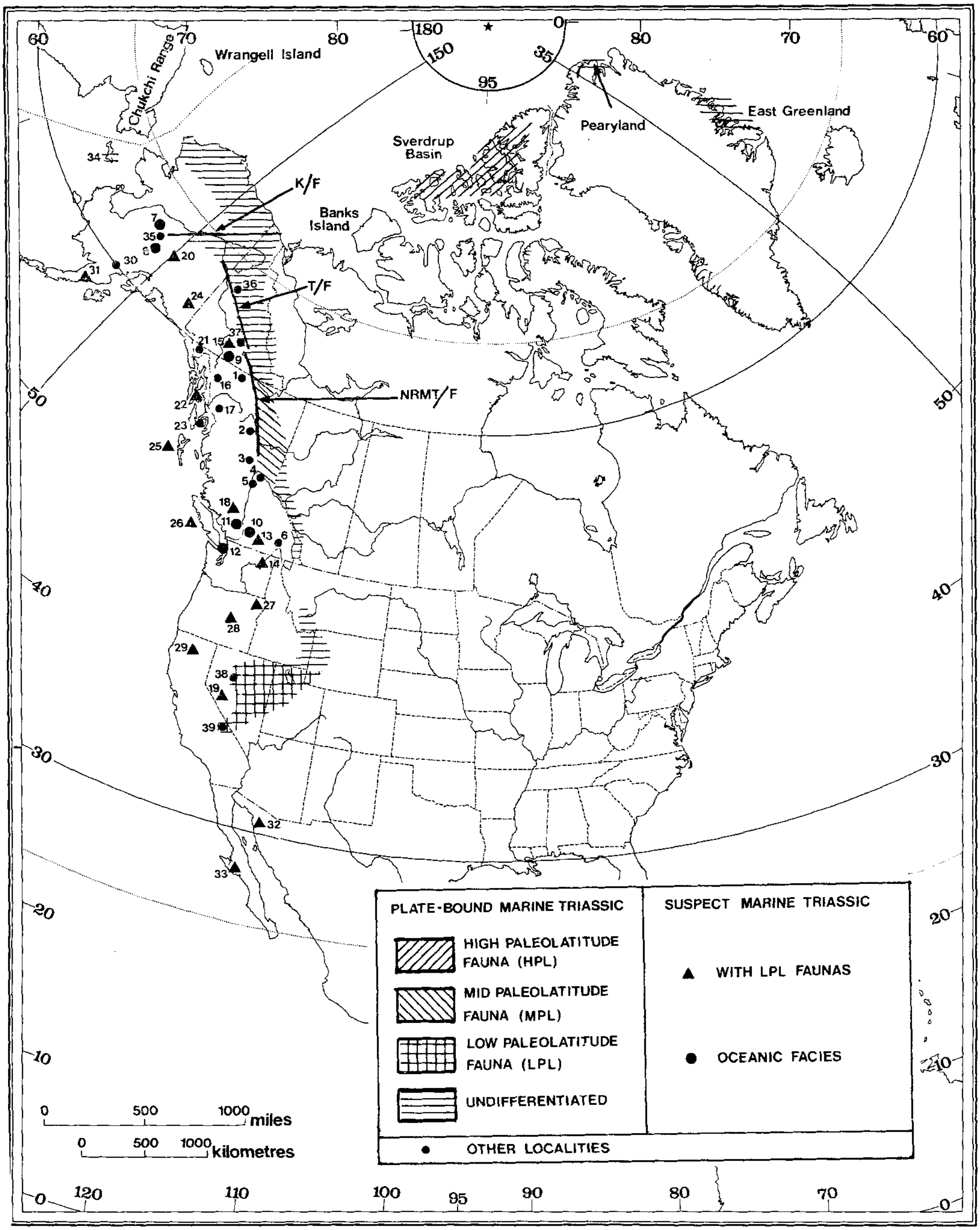
Northern California
29. Shasta Country

Peninsular terrane (30—31)
30. Iliamna Lake
31. Puale Bay

Terrane with Hallstatt facies (?)
32. Mina el Antimonio

Vizcaino terrane
33. Punta san Hipolito

Other localities in text
34. St. Lawrence Island
35. Nixon Fork terrane
36. Chert Mountain
37. St. Cyr Range
38. Northwestern Nevada (Star Peak and Auld Lang Syne groups
39. Inyo Range.


Wrangell Island
Chukchi Range
Sverdrup Basin
Pearyland
East Greenland
Banks Island
K/F
T/F
NRMT/F
PLATE-BOUND MARINE TRIASSIC
HIGH PALEOLATITUDE FAUNA (HPL)
MID PALEOLATITUDE FAUNA (MPL)
LOW PALEOLATITUDE FAUNA (LPL)
UNDIFFERENTIATED
SUSPECT MARINE TRIASSIC
WITH LPL FAUNAS
OCEANIC FACIES
OTHER LOCALITIES
0 500 1000 miles
0 500 1000 kilometres

luscs etc. Wrangellia (JONES et al., 1977) is a good example. The Alexander terrane, Stikinia and Quesnelia are others (Figure 1). Faunas from these terranes provide data for paleoclimatic and paleozoogeographic interpretations. Thick piles of volcanic rock and their sedimentary derivatives occur in the Triassic successions. The age and chemistry of the volcanic rocks is commonly different in each terrane, and the position and nature of the volcanic rocks generally contributes to the terrane's diagnostic characters. A summary of the salient features of the volcanic rocks has been provided by SOUTHER (1977). Most of these terranes also have substantial masses of biogenic carbonate rock.

Localities where terranes have provided significant faunas are on Figure 1. There are many other localities for Triassic faunas but as presently known they do not contribute significant data. The mosaic of suspect terranes is one of great structural complexity. Strips of ultrabasic rock suggest suture zones; mighty dextral faults have been recognized; overthrust nappes are also evidently present. The complexity of the Triassic geology of Alaska is dramatically illustrated in the recent report on the Upper Chulitna district (Locality 20), where three terranes with different coeval Triassic sequences are juxtaposed (JONES et al., 1980). Several maps (e. g. MONGER et al., 1982, fig. 1) show that terranes with shallow water Triassic formations (Wrangellia, Alexander, Stikinia, Quesnelia) are in places separated by terranes with the oceanic facies. I am not qualified to make tectonic interpretations to account for the present juxtaposition of these terranes. A paleogeographical interpretation seems to be one of shoals and islands, intermittently volcanic, shedding detritus into adjacent troughs and basins. Around were banks where conditions were favourable for the growth of biogenic carbonate sediments. Between the islands etc. were deeper basins in which were deposited the rocks of oceanic facies.

The boundary between the plate-bound and suspect Triassic is by definition tectonic and is seldom exposed. There are many problems concerning the exact position, some of which must be considered.

The boundary in Alaska has been drawn following the interpretation of CHURKIN and TREXLER (1981, p. 11), with an offset at the Kaltag fault (K/F, Figure 1). This accomodates the Triassic of the Nixon Fork terrane (Locality 35), which has Norian faunas related to those of the plate (JONES and SILBERLING, 1979, p. 19).

In Canada all Triassic east of the Tintina (T/F) and Northern Rocky Mountain trench (NRMT/F) faults is certainly plate-bound. However in Yukon, TEMPELMAN-KLUIT (1979) has shown that Triassic, which he interprets as plate-bound, also occurs west of the T/F, e. g. in the St. Cyr Range (Locality 37). In his interpretation the edge of the plate was some 150 km west of the T/F, at the Teslin suture.

Farther to the south, in what may be called the British Columbia border zone, Triassic rocks occur in a belt west of the NRMT/F and the Rocky Mountain trench (Localities 1—6, GABRIELSE, 1963, p. 13; MONGER, 1977 a, pp. 23—27; ARMSTRONG, 1949, p. 58; TIPPER, 1961; CAIRNES, 1934, p. 60). All are in areas of great structural complexity. The fossiliferous Triassic strata are associated with volcanic and other unfossiliferous rocks. The volcanic rocks are generally regarded as Triassic. But their age does not seem to be well established and it seems possible that at least some of the fossiliferous rocks might be pieces of Triassic North America, associated by tectonic entanglement with volcanic rocks that were far away, or had not even formed, in Triassic time. In this interpretation the Triassic rocks of the border zone would be parts of a purely sedimentary succession, related to that of the plate, particularly that of the St. Cyr Range, mentioned above.

The nature of the plate-terrane boundary in the western United States also presents problems. In the eastern part of the Cordillera, typified by sections in Montana, Wyoming, southern Idaho, Utah and eastern Nevada, only the Lower Triassic is marine; younger strata are mostly red beds. These Triassic formations (Dinwoody, Thaynes etc.) were certainly deposited on the North American plate. In western Nevada marine rocks of Middle and Upper Triassic age are also present. Some are regarded as deposits on the plate, others as suspect. The rocks that are of critical significance in the present context are the Star Peak and Auld Lang Syne groups at Locality 38 (BURKE and SILBERLING, 1973; NICHOLS and SILBERLING, 1977), because they alone have the capability of providing the Middle and Upper Triassic faunal data for the LPL province. According to SPEED (1979, fig. 1) these rocks were deposited beyond the western limit of the sialic American continent. They are in the area affected by the Permo-Triassic Sonoma orogeny (SILBERLING and ROBERTS, 1962). There nevertheless seems to be general agreement that these rocks were deposited on a terrane that had accreted to the North American plate before the end of the Lower Triassic (SILBERLING, 1973; KING, 1977, p. 150; DICKINSON, 1977, p. 148; DAVIS et al., 1978; BURCHFIEL, 1980, p. 68; HAMILTON, 1980, p. 38). The Luning sequence (MULLER and FERGUSON, 1939), which is farther west (Locality 19), is an important source of Triassic faunal data, but it includes Middle and Upper Triassic volcanic rocks (SILBERLING, 1973, p. 354; OLDOW, 1978) and is generally regarded as suspect.

The Question of a Siberian Connection

This question must be considered because it is critical to understanding the northwestern coast of Pangaea (Figure 2). Triassic rocks occur in the Chukchi Range and on Wrangell Island (Figure 1). At least some of the faunas indicate affinity with the MPL, or more likely the HPL province (Table II). However, although now fairly close to North America, the rocks were probably laid down far away. Compared with those of St. Lawrence Island and the Alaska north slope, they are about 50 times thicker (about 5000 m), and composed of terrigenous sandstone, siltstone and shale, interpreted as of southern derivation (VERESHCHAGIN and RONOV, Eds., 1968, volume III, plates 1—10). This suggests that there was no continuity between Siberia and Alaska and supports the tectonic interpretations of HAMILTON (1967, 1970, p. 2572), STONELEY (1971, p. 627) and FREELAND and DIETZ (1973), all of whom advocate the post-Triassic anticlockwise motion of northern Alaska indicated on Figure 2. The evidence does not support the contrary views of CHURKIN (1972), FUJITA (1978, p. 170) and McGEARY and BEN-AVRAHAM (1981), who consider that there has been little or no movement of this kind.

Plate-Bound Faunas: The Standard for Comparisons

The North American plate preserves autochthonous or parautochthonous marine Triassic over a latitudinal range of about 46 degrees, from the Inyo Range in

California (Locality 39) (36 N) to northern Ellesmere Island (82 N). The whole of the Triassic except the uppermost is represented by marine faunas (Table I). Depending on the time interval up to three faunal provinces have been distinguished. Figure 1 shows the position of the provinces; Table II lists the diagnostic fossils and gives their distribution. The position on the provinces is related to present-day latitude. The province now at low latitude has intrinsic characters (coralline limestones etc.) suggestive of deposition in warm water. These are absent in the provinces now at higher latitude, suggesting that their faunas inhabited cooler waters. The differences are accordingly taken to justify interpretation of the faunal provinces as indicators of paleolatitude. They are here designated the LPL, MPL and HPL provinces (low, mid, high paleolatitude). As mentioned below, the LPL faunas have much in common with those of the Tethys, for which there are now paleotemperature determinations indicating deposition in warm water (FABRICIUS et al., 1970). Paleotemperatures determined from Lower Triassic ammonoid shells from Arctic Siberia indicate colder water (ZACHAROV, 1974; ZACHAROV et al., 1975).

The position of the provinces, where determinable, is roughly the same for each time interval, but further work may lead to refinement.

The character of each province is defined on data from the American plate. This circumvents problems inherent when defining the characteristics of faunal provinces from occurrences on terranes that may have moved appreciably in relation to one another since Triassic time, e. g. those of Tethys.

From the North American plate-bound paleomagnetic data IRVING (1977) places the Triassic pole at 64 N, 93 E. Using this pole, the area in which the HPL province is defined is at about 60 N, MPL at about 40 N, LPL at about 15 N.

Sections in Nevada, Utah and southern Idaho provide the diagnostic data for the LPL; northeastern British Columbia for the MPL; the Sverdrup Basin for the HPL province (Figure 1). The principal sources for the data in Table II are SMITH (1927, 1932), KUMMEL (1969), SILBERLING (1956, 1962, 1970), SILBERLING and WALLACE (1969), STANLEY (1979) and TOZER (1958, 1961, 1967, 1980).

All the LPL data for the Middle and Upper Triassic are from the Star Peak and Auld Lang Syne groups of Nevada (BURKE and SILBERLING, 1973; NICHOLS and SILBERLING, 1977). These groups, as already mentioned, are believed to have been deposited on the North American plate. Although the assumption that these beds were laid down on the plate greatly strengthens the data base by providing the only LPL control for the Middle and Upper Triassic, these data are not indispensable for recognizing the existence of a LPL province. Lower Triassic LPL data are available from eastern Nevada, Utah and southern Idaho, from sections that were unquestionably on the plate.

Interpretation of the faunas from northeastern British Columbia as diagnostic for the MPL province is critical to the tectonic arguments advanced. Explanation is necessary. The Triassic formations of the west and central parts of this miogeoclinal sequence have excellent ammonoid successions in dark siltstones and limestones. The limestones are commonly coquinites of HALOBIA and MONOTIS shells, with nests of ammonoids in concretions. This, however, is not the only facies developed in northeastern British Columbia. In the Ladinian and Carnian the dark ammonoid beds are replaced to the east by calcareous siltstone and sandstone with some bioclastic limestone and evaporitic rocks. Details on the petrology

Table I

Biochronological standard for the Triassic from North American data (Silberling and Tozer, 1968; Tozer, 1981). x = exact correlative. o = approximate correlative. c = correlative from conodont occurrence in Cache Creek Group (Orchard 1981). Circled symbols in Tethys column indicate occurrences in Hallstatt limestone facies. Solid vertical lines indicate intervals during which low, mid and high paleolatitude (LPL, MPL, HPL) provinces are distinguished.

			AMERICAN PLATE			SUSPECT	TETHYS
			L P L	M P L	H P L		
UPPER TRIASSIC	UPPER NORIAN	Crickmayi				x	x
		Amoenum				x	(x)
		Cordilleranus	x	x	x	x	(x)
	MIDDLE NORIAN	Columbianus	x	x	x	x	(x)
		Rutherfordi		x		x	(x)
	LOWER NORIAN	Magnus	x	x		x	(x)
		Dawsoni		x		x	(x)
		Kerri		x		x	(x)
	UPPER CARNIAN	Macrolobatus		x		x	(x)
		Welleri		x	x	x	(x)
		Dilleri	x	x	o	x	(x)
	LOWER CARNIAN	Obesum		x	o	x	(x)
		Desatoyense	x	x	o	x	(x)
MIDDLE TRIASSIC	LADINIAN	Sutherlandi	x	x	o		(x)
		Maclearni	x	x	o		(x)
		Meginae	x	x	o		(x)
		Poseidon	x	x	o	o	(o)
		Subasperum	x	x			(o)
	UPPER ANISIAN	Occidentalis	x	o			(x)
		Meeki	x	o	o		(o)
		Rotelliformis	x	x	x		(x)
	MIDDLE ANISIAN	Shoshonensis	x	x			(x)
		Hyatti	x	x	x		(x)
	LOWER ANISIAN	Caurus	x	x	x		(o)
LOWER TRIASSIC	SPATHIAN	Haugi	x	o	o		(o)
		Subcolumbites	x	o	o		(o)
		Columbites	x				o
	SMITHIAN	Tardus	x	x	x		(x)
		Romunderi	x	x	x	x	(x)
	DIENERIAN	Sverdrupi		x	x	c	
		Candidus	x	x	x		x
	GRIESBACHIAN	Strigatus	o	o	x		o
		Commune			x		x
		Boreale			x		
		Concavum			x		o

are in GIBSON (1975). These rocks clearly indicate a variety of shallow water environments. Brachiopod and bivalve faunas of low taxonomic diversity are present. Near Mount Laurier there are large bioclastic shell banks that probably formed on a slope between the shallow and deeper parts of the basin (GIBSON, 1975, p. 60), but there are no coral beds or reefs. Evidently the absence of LPL indicators was not due to the lack of suitable bathymetric conditions, nor to overwhelming clastic sedimentation. It seems safe to conclude that corals and megalodonts failed to colonise this province because the water was too cold.

At some intervals the ammonoid and pelagic bivalve faunas are remarkably cosmopolitan. The best example is in the late Smithian Tardus Zone (Table I), when identical ammonoids (e. g. WASATCHITES) inhabited all three provinces and many other parts of the world as well (TOZER, 1971, p. 1005). Some Griesbachian and Dienerian faunas are similarly distributed (KUMMEL, 1973, pp. 225, 228).

Early Smithian, early Spathian and Anisian ammonoid faunas permit the characterization of the LPL province but the faunas of British Columbia and the Sverdrup Basin are so similar that MPL and HPL provinces cannot be distinguished. All the early Smithian faunas considered are probably not exactly the same age (TOZER, 1978, pp. 27—30). In spite of this the failure of OWENITES etc. to extend beyond the LPL province is taken to be significant. The stratigraphic interval in which it is to be expected is exposed in a suitable facies in dozens of places in Alberta, British Columbia, Yukon and the Sverdrup Basin but it has never been found. Presumably OWENITES never lived there.

In the Ladinian and Carnian, and at intervals in the Norian, there are grounds for recognizing three provinces. Faunas of the LPL province are immediately segregated by virtue of their corals, spongiomorphs, megalodont bivalves and MONOTIS SALINARIA Bronn, all unrepresented in the MPL and HPL faunas. STANLEY (1976, 1981) questions that true reefs were formed but the presence of substantial coral beds is undeniable. The LPL and MPL provinces have closely similar ammonoid faunas at some levels (Dilleri, Magnus, Columbianus, Cordilleranus zones, Table I). The absence of some ammonoid faunas in the LPL province (Welleri, Macrolobatus, Kerri, Dawsoni, Rutherfordi zones) is probably related to the absence of suitable facies in the Star Peak and Auld Lang Syne groups. As shown on Table I, ammonoids of all these zones occur in the Hallstatt limestones of Tethys which are evidently deposits of the equatorial belt. Taking world-wide data into account it seems likely that these ammonoids may have inhabited the LPL belt, despite the fact that they have not yet been found.

Some of the attributes of the MPL and HPL provinces (e. g. the absence of corals) are negative. Not all, however. They have a distinctive succession of Lower Triassic posidonias (POSIDONIA MIMER Oeberg, Smithian; P. SIBIRICA Kurushin, early Spathian; P. ARANEA Tozer, late Spathian), unknown in the LPL province. AMPHIPOPANOCERAS (Anisian) and Nathorstitidae (Ladinian) of the upper provinces contrast their faunas with those of LPL. PROCLYDONAUTILUS NATOSINI McLearn, which ranges from the Dawsoni Zone to the Columbianus Zone is also MPL-HPL, being known from northeastern British Columbia, Yukon and Ellesmere Island (PETRYK, 1969, p. 7). In the Norian the upper belts have diagnostic monotids (EOMONOTIS, Columbianus Zone; MO-

NOTIS OCHOTICA (Keyserling), Cordilleranus Zone). MONOTIS SUBCIRCULARIS Gabb is in the LPL and MPL provinces but not the HPL.

Most characters that distinguish the HPL and MPL provinces are negative. HPL ammonoid faunas are much less diverse than MPL. This is seen by comparing the Ladinian NATHORSTITES faunas of British Columbia with those of the Sverdrup Basin. In British Columbia more than a dozen other ammonoid genera, mostly also known in the Tethys, are associated with the Nathorstitidae. In the Sverdrup Basin (HPL), also in Alaska and Yukon, NATHORSTITES is alone or with NEOCLADISCITES, a genus unknown in the MPL province. This may provide the MPL province with a unique Ladinian attribute.

Everything about the Sverdrup Basin sequence suggests that there was continuous marine sedimentation between the Carnian (Welleri Zone) and Upper Norian (Cordilleranus Zone). Marine rocks are there but with few ammonoids (Table 1). MONOTIS OCHOTICA is known from at least four localities, but, unlike occurrences in the MPL province, HETERASTRIDIUM, MONOTIS SUBCIRCULARIS, GNOMOHALORITES and RHABDOCERAS are not associated. Presumably they were never there.

Suspect Faunas and their Tectonic Significance

Triassic faunas are known from the belt of suspect terranes that extends from southern Alaska to Mexico, a latitudinal range of 36 degrees (Figure 1). Distribution of significant fossils is given in Table II. Lower and Upper Triassic faunas throughout this belt have forms diagnostic for the LPL province defined on the plate. The faunas from the British Columbia border zone, if truly on a suspect terrane, may be an exception. They include Carnian ammonoids, Norian MONOTIS SUBCIRCULARIS, and a possible EOMONTIS at locality 5. The evidence suggests the MPL province.

Middle Triassic fossils are known from the suspect terranes but they are mostly DAONELLA. As presently known they cannot be certainly attributed to one or other of the provinces.

The only Lower Triassic suspect fauna amenable to interpretation is early Smithian, from the Chulitna district, Alaska and Kelly Hill, Washington (Kuenzi, 1965) (Localities 14, 20). From comparing the position of the northern one, in the Chulitna terrane, with occurrences on the North American plate, Nichols and Silberling (1979, p. 84) concluded that it "has been displaced from a site much farther south than its present location".

A similar argument for displacement by comparing Upper Triassic faunas from different parts of British Columbia and Yukon was proposed by Tozer (1970), p. 653). More specific evidence is now provided.

At two localities in the suspect terranes Carnian-Norian faunas with scleractinian corals (LPL) are today north of the 60th parallel (Silberling and Tozer, 1968, p. 48; Tozer, 1958, p. 10) (Figure 1, Table II). Comparable faunas on the plate are 3000 km to the south.

Middle Norian Columbianus zone faunas lacking EOMONOTIS, which characterize LPL assemblages on the plate, are known from at least three localities in the suspect terranes (Table II). All occur at a higher latitude than those on the plate. The northernmost, in the Queen Charlotte Islands, is at about the same latitude as the MPL plate-bound occurrences. EOMONOTIS records from Vancouver Island (TOZER, 1967, p. 81; SURDAM et al. 1964) are now believed to be incorrect. The Columbianus Zone is a substantial division of Triassic time, amenable to division (TOZER, 1971, p. 1019; TATZREITER, 1981). Lest it be supposed that the differences merely indicate that the suspect and plate-bound faunas are not coeval, it may be said that the divisions of the Columbianus Zone have been recognized in both.

Pronounced evidence for displacement is shown in the Upper Norian Cordilleranus Zone. Contemporaneity of the beds in question has been documented (TOZER, 1980, p. 864). In the suspect terranes the LPL indicator MONOTIS SALINARIA occurs as far north as the Wrangell Mountains (Locality 24) (SILBERLING and TOZER, 1968, p. 48) and at several other localities to the south (Table II). All are north of the plate-bound occurrence in the Clan Alpine Range (Locality 38, SILBERLING and TOZER, 1968, p. 31). Some are aligned with the MPL province on the plate. As recognized by WESTERMANN (1973), the distribution of different MONOTIS species has considerable paleogeographic significance, with MONOTIS SALINARIA indicating affinity with the faunas of Tethys.

The youngest Triassic faunas (Amoenum and Crickmayi zones) occur in the suspect terranes but are unknown on the plate (Table I). The southernmost is in the Luning sequence (Locality 19), the northernmost in Yukon (Locality 15). The coralline limestone of Iliamna Lake, Alaska (Locality 30) is more or less of this age (STANLEY, 1976). Details on the composition and distribution of these faunas are given in TOZER (1980). They cannot be used to estimate the amount of displacement because there are no certainly plate-bound faunas of the same age for comparison. Although they do not provide positive evidence for displacement the intrinsic character of these youngest Triassic faunas, which include corals and spongiomorphs, is suggestive of low paleolatitude. The nature and distribution of these faunas is thus compatible with their having been displaced northward, like those of Smithian, Carnian and earlier Norian times. Some of these suspect faunas, although without counterparts on the American plate, nevertheless provide data that seem to have a bearing on the relative position of individual terranes in the Triassic. These are benthonic faunas which include brachiopods, gastropods, bivalves and echinoids. The faunas are rich in variety, but few have been described. Some descriptions are in GABB (1870), CLAPP and SHIMER (1911), LEES (1934) and MCLEARN (1942). Although they do not assist in making comparisons with faunas on the plate, there are similarities between the faunas of individual terranes that seem significant. These faunas include CASSIANELLA LINGULATA GABB (= C. BEYRICHI Var. CRICKMAYI McLearn), PLICATULA PERIMBRICATA Gabb, and MINETRIGONIA SUTTONENSIS (Clapp and Shimer). Data on the distribution of these and other species have been given by N. J. SILBERLING (in BERG, 1973, p. 24) and TOZER (1967, pp. 75—80). M. SUTTONENSIS is now also known from Carmine Montain (Locality 21). The data show that these benthonic bivalves inhabited at least four different terranes (Luning, Wrangellia, Alexander, Stikinia) suggesting that all were in the same zoogeographic province. This perhaps carries more weight than the paleomagnetic interpretation, mentioned below, according to which the Alexander and Wrangellia terranes were widely separated in latitude.

To summarize the data from the suspect terranes: Triassic faunas occur through

Table II

Distribution of fossils that characterize the LPL, MPL and HPL faunal provinces. Numbers refer to localities on Figure 1.

	NORTH AMERICA – PLATE BOUND: LPL	NORTH AMERICA – PLATE BOUND: MPL	NORTH AMERICA – PLATE BOUND: HPL	NORTH AMERICA – SUSPECT: Nicola (13)	Kelly Hill (14)	Lewes River Group (15)	Tyaughton Group (18)	Chulitna terranes (20)	Keku Islets area (22)	Wrangell Mountains (24)	Queen Charlotte Islands (25)	Vancouver Island (26)	Wallowa Mountains (27)	Suplee-Izee area (28)	Shasta County (29)	Puale Bay (31)		TETHYS	NEW GUINEA	NEW CALEDONIA	NEW ZEALAND	CHUKCHI RANGE
Upper Norian (Cordilleranus Zone)																						
Heterastridium	●	●						●										●				
Monotis salinaria	●			●						●	●	●				●		●				
Monotis subcircularis	●	●		●		●	●	●	●	●	●	●			●					●	●	
Monotis ochotica		●	●																	●	●	●
Gnomohalorites, Rhabdoceras etc.	●	●				●	●					●						●				
Middle Norian (Columbianus Zone)																						
Eomonotis		●	●																		?	●
Himavatites, Steinmannites etc.	●	●									●	●	●					●				
Neohimavatites		●	●																			
Proclydonautilus natosini		●	●																		●	
Carnian-Lower Norian																						
Scleractinian corals	●			●		●	●		●	●	●	●	●	●	●			●				
Megalodontidae	●						●	●										●				
Ladinian																						
Scleractinian corals	●																	●				
Protrachyceras archelaus group etc.	●	●																●				
Nathorstitidae		●	●																			
Neocladiscites			●																			
Middle-Upper Anisian																						
Paraceratites	●																	●				
Acrochordiceras, Cuccoceras	●																	●				
Balatonites	●																	●				
Amphipopanoceras		●	●																●		●	
Early Spathian																						
Posidonia sibirica		●	●																			
Tirolitinae, Columbitidae	●																	●				
Early Smithian																						
Posidonia mimer		●	●																			●
Owenites	●				●			●										●			●	
Metussuria, Lanceolites, Aspenites	●							●														

TABLE II

a latitudinal range of about 36 degrees. In Alaska and Yukon they are now about 3000 km north of their counterparts on the North American plate; about 1500 km north of the MPL province. This suggests that since Triassic time dextral movement in the order of 1500—3000 km has affected the terranes with these faunas. From the arguments employed, 1500 km is the minimum, 3000 km is compatible with the data, but not necessarily the maximum. So far it has not been possible to make any suggestions concerning the relative amount of displacement of individual terranes. All except for the possible suspect terrane now in the British Columbia border zone, have LPL faunas probably indicative of deposition within 30 degrees of the Triassic equator (Figure 2).

These conclusions agree with most, but not all of the paleomagnetic data. Interpretations for Wrangellia and Quesnelia (HILLHOUSE, 1977; PANUSKA and STONE, 1981; YOLE and IRVING, 1980; MONGER and IRVING, 1980) give low paleolatitudes, in agreement with the indications from the faunas. Data from the Alexander terrane, on the other hand, are said to indicate that this terrane has not been displaced, latitudinally, with respect to the plate (HILLHOUSE and GROMMÉ, 1980). Against this interpretation it should be noted that N. J. Silberling (in MUFFLER, 1967, p. C 30) has identified Upper Triassic LPL faunas from the Alexander terrane at Locality 22, also, as noted above, the youngest Triassic faunas suggest that the Alexander and Wrangellia terranes were not far apart in the Triassic.

Comparisons with Tethys

Triassic paleogeographic reconstructions have a large wedge of seawater encroaching the east side of the Pangaea supercontinent (Figure 2). This is generally known as Tethys, although a case can be made for calling it Palaeotethys (JENKYNS, 1980). Tethys will do for now. How much of it was truly oceanic seems to be uncertain. The seaway was probably within 30 degrees north and south of the Triassic equator. There is general agreement that Tethys had no western connection with Panthalassa.

This discussion will be concerned with faunas in Tethys that resemble those in North America. There are two main kinds that are relatively well known. One is typified by the development in the Mediterranean area; the other by occurrences in the main ranges of the Himalayas. There is also at least one more kind of development, typified by the Triassic in China north of the Himalayas. Because less well known, at present little can be done in making comparisons with the Chinese faunas.

Characteristic faunal facies in the Mediterranean area are: thick carbonate formations with megalodont bivalves (Dachstein facies); coralline limestones and marls (Zlambach facies), and the red, commonly manganiferous ammonoid-bearing Hallstatt limestones. All these have faunas that are generally believed to be of equatorial and low latitudes. This, the classical interpretation, has now been confirmed by paleotemperature determinations (FABRICIUS et al., 1970).

The ammonoid and bivalve faunas of the Hallstatt limestones are of particular interest in the present context. These limestones occur throughout Tethys, from Austria, to northern Italy, Hungary, Rumania, Yugoslavia, Albania, Greece and Turkey. Then there is a gap but the facies reappears as olistostromes in the Indus

Suture zone (the Tibetan facies of DIENER, 1912, p. 132). The last appearance is in Timor, as blocks and olistostromes. In these rocks, which were probably the deposits of sea mounts, many ammonoid zones are commonly preserved in a small thickness. Impressive documentation of this feature is provided by the recent work of TATZREITER (1981), who has has described a block in Timor, 1 m thick, representing three Norian zones (Rutherfordi, Columbianus, Cordilleranus). There is nowhere a complete section for the Triassic in the Hallstatt facies but except near the base and the top (Table 1) virtually every interval of Triassic time is represented in one place or another. The ammonoid faunas are the most varied known, with both rough (trachyostracous) and smooth (leiostracous) forms. The latter commonly predominate in number of specimens. Halobiid and monotid bivalves also occur. Most significant for comparing with North America are MONOTIS SALINARIA Bronn, M. HAUERI Kittl and M. KAUKASICA Wittenberg. The last two closely resemble MONOTIS SUBCIRCULARIS Gabb. EOMONOTIS and MONOTIS of the OCHOTICA group are evidently absent (WESTERMANN, 1973). The monotids of Tethys thus resemble those of the LPL province. Ammonoids from the Hallstatt which are restricted to the American LPL faunas include OWENITES (Smithian), SUBCOLUMBITES, TIROLITES, and several other early Spathian genera; also ACROCHORDICERAS, BALATONITES and other diagnostic LPL Anisian genera. In the Ladinian, Carnian and Norian the trachyostracous ammonoids had a wider paleolatitudinal range, many from the British Columbia MPL belt being like those in the Hallstatt. Compared with the Hallstatt the MPL faunas have relatively few leiostracous ammonoids. The corals and megalodont bivalves of the American LPL faunas suggest an environment and paleolatitude comparable with that of the Zlambach and Dachstein formations. To summarize: fossils diagnostic of the LPL province on the American Plate are also in the Hallstatt — Dachstein — Zlambach formations of the Mediterranean area. In the Lower Triassic and Anisian this is shown by the ammonoid faunas; in the Ladinian through Norian by scleractinian corals; in the Norian by megalodont bivalves and MONOTIS SALINARIA.

The Hallstatt facies is unknown on the American Plate and in the suspect terranes. There is, however, one possible occurrence in North America, at Mina el Antimonio, Sonora, Mexico (Locality 32) (BURCKHARDT, 1930). Ammonoids of the Upper Carnian Dilleri Zone were identified by J. P. SMITH (in KING, 1939, p. 1657) from this locality. Those that I have seen, from the collection of Yale Peabody Museum, are in red limestone, superficially, at least, like the Hallstatt. The Upper Triassic fossils from other localities in Mexico (BURCKHARDT, 1930, p. 2; DE CSERNA, 1961; FINCH and ABBOTT, 1977) are not of this facies.

Also important for comparisons with North America are the sections in the main ranges of the Himalayas, in Kashmir, Spiti, Nepal and China (Himalayan facies of DIENER, 1912, p. 15). These beds are south of the Indus suture although in the Kiogars ophiolites of the suture zone, with blocks of Hallstatt rock, have been thrust over the Himalayan facies (GANSSER, 1964, p. 124). The rocks of the Himalayan facies have been tectonically disturbed but there seems to be general agreement that they were bound to the Indo-Australian plate (STOCKLIN, 1980, p. 7). The sequence, like that on the American plate, is purely sedimentary. Hallstatt facies is absent but rich ammonoid faunas ranging in age from Lower Griesbachian to Norian occur in dark limestones. MONOTIS SALINARIA indicates the Cordilleranus Zone. Above is the Kioto limestone, which has megalodonts. Corals are apparently absent. The ammonoids permit close correlation with both the Hallstatt occurences and with North America. Some of the Lower Triassic faunas are so cosmopolitan that they carry no paleozoogeographic message. Ladinian, Carnian and Norian faunas closely resemble those of the Hallstatt and those of the LPL and MPL provinces of North America. MONOTIS SALINARIA indicates affinity with the Hallstatt and the LPL province.

At this stage no detailed attempt will be made to analyse the Triassic of northeast Tethys as represented in China, and south east Asia. Nor will the important Triassic occurrences of eastern Asia be considered except to note in passing that both plate-bound belts and suspect terranes appear to be preserved (Figure 2). The complexity of the Triassic geology of China is shown in the recent report by WANG et al. (1981) indicating vast tracts of Triassic, with thick sequences of clastic and volcanic rocks, in a series of belts north of both the Neotethys and Palaeotethys sutures as defined by STÖCKLIN (1980), and SENGOR, YILMAZ and KETIN (1980). Then there are the carbonates and evaporites of the Yangtze platform which must be accomodated somehow. A first glance at the data shows that there are faunas inviting comparison with those of the North American LPL province, e. g. the OWENITES and SUBCOLUMBITES faunas of Guangxi, on the Yangtze platform (CHAO, 1959). The LPL indicator MONOTIS SALINARIA is reported from a belt between the Neo and Paleotethys sutures (WANG et al., 1981, p. 6).

The North American and Asiatic Triassic developments seem to be mirror images (Figure 2). Plate-bound are the relatively homogeneous sedimentary sequences of Verkhoyanie, the Himalayas and the eastern tract of the American Cordillera, welded respectively to the Eurasian, Indo-Australian and North American plates. Away from the plate, each of the plate-bound sequences is flanked by heterogeneous tracts composed of both sedimentary and volcanic rocks. Marine faunas are found nearly everywhere. Their analysis and interpretation presents an exciting challenge.

Fig. 2. Distribution of Marine Triassic — Then and now.

Polyconic projection. Triassic globe not contracted. Numbers identify sedimentary areas, now suspect terranes, with faunas amenable to paleolatitudinal interpretation. Not shown are the oceanic terranes. Polarity of terranes within 30 degrees north and south paleolatitude uncertain. Polarity of terranes 14—16 determined (see text). Longitude of sedimentary areas east of spreading ridge (dashed line) estimated on the assumption that all had accreted with one another and the North American plate before the end of the Jurassic, 1000 km of Atlantic spreading, 4000 km of Pacific spreading being accomodated. Areas 1—11 are now accreted to the North American Plate (See Figure 1). Interpretation of South America and Asia schematic.
1: possible MPL volcanic terrane now in the British Columbia border zone. 2: Quesnelia. 3: Stikinia. 4: Chulitna terranes. 5: Luning terrane. 6: Alexander terrane. 7: Wrangellia. 8: Shasta County, California. 9: Peninsular terrane. 10: Vizcaino terrane. 11: Mina el Antimonio. 12: Peru. 13: Chile. 14: Northern New Guinea. 15: New Caledonia. 16: New Zealand. 17: Northeast Siberia terranes. 18: Japan and Primor'ye. 19: Yangtze Platform. 20: Gandise-Hengduan terranes. 21: Qilian-Bayanhar terranes. 22: Northern Tethyan Himalaya. 23: Timor. 24: Kiogars. 25: Hallstatt occurrences of Mediterranean area.

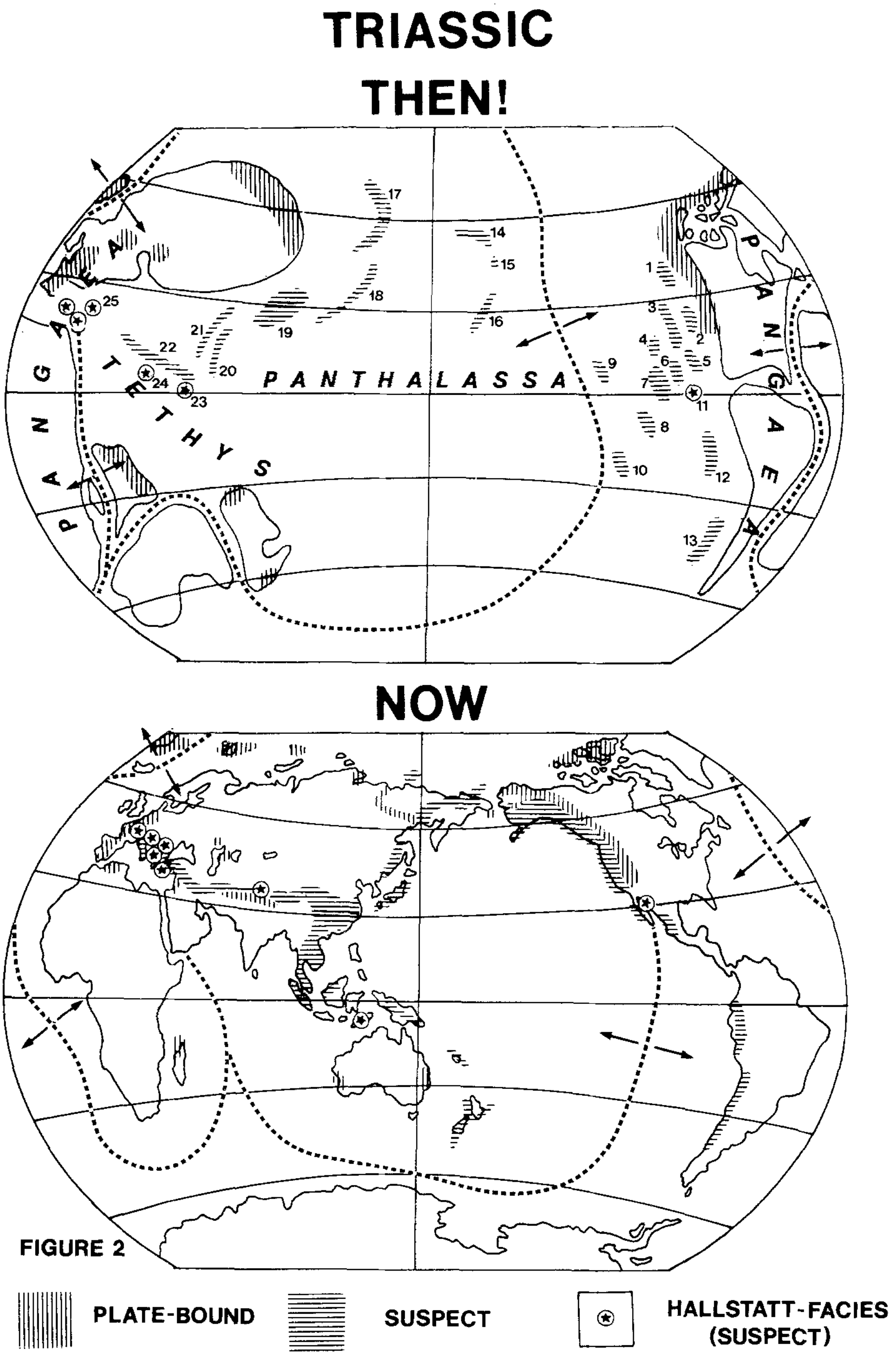

TRIASSIC
THEN!
P A N T H A L A S S A
T E T H Y S
P A N G A E A
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
NOW
PLATE-BOUND
SUSPECT
HALLSTATT-FACIES (SUSPECT)

FIGURE 2

A general picture of Triassic world-wide ammonoid distribution seems to indicate an equatorial belt, typified by the red Hallstatt facies, with rich faunas of both leiostracous and trachyostracous forms. Between the Ladinian and Norian most of the trachyostracous taxa also ranged well to the north (MPL province), appreciably to the south (Himalayas). At these times closely similar trachyostracous ammonoids appear to have ranged through a latitude of some 70 degrees (40 N to 30 S) about the Triassic equator. The American data suggest that relatively few penetrated farther north. If, like KOZUR (1973), one is looking for a "southern boreal" province, the Himalayas provide a possible occurrence, but the presence of megalodonts and MONOTIS SALINARIA suggest that this belt was not so very far south of the Triassic equator. There seem to be no reliable data to test the extent of penetration to the south. New Zealand, as will be mentioned, must be treated with suspicion. Apart from the Himalayas the only marine Triassic rocks bound to pieces of Gondwanaland are in Australia and Madagascar (Figure 2). All are Lower Triassic and none gives a clear paleolatitudinal signal.

Summary: Towards a Triassic Paleogeography

Paleogeographic reconstructions for the Triassic, since Wegener's time, have viewed the globe as mostly land (Pangaea) on one side, mostly or wholly ocean (Panthalassa) on the other. At equatorial and mid-paleolatitude the east side of Pangaea had a big marine embayment — the Tethys. All the evidence suggests that the west end of Tethys was closed in the Triassic. Apparently there was no direct marine communication between Tethys and the east side of Panthalassa. There was no Triassic Panama Canal.

Most paleogeographic maps view the Triassic world from the Pangaea side. For a change I have taken the conventional Pangaea reconstruction, the paleolatitudes of IRVING (1977), transferred them to a polyconic projection via an eight inch globe, and viewed the other side (Figure 2).

Now that it is becoming recognized that the North American Cordillera includes not merely one or two but more than twenty discrete terranes on which Triassic rocks were deposited, Panthalassa may be viewed, not as a gigantic landless ocean as by KRISTAN-TOLLMANN and TOLLMANN (1981) but as a body of water liberally scattered with shoals and islands of one kind or another.

A Triassic geography of Panthalassa to satisfy the observed distribution of marine faunas and the variations in stratigraphy might be as follows. Starting at the eastern shore, as indicated by what is found on the western edge of the North American Plate, much of the coast was evidently of Atlantic type. The marine sediments were in the form of a miogeocline tapering to a very thin edge (as at Chert Mountain). These miogeoclinal rocks, at least in Canada, and apparently also Alaska show no indication of nearby tectonism or volcanism. In Nevada it may have been different early in the Triassic, with the disruption brought about by the Sonoma orogeny and the subsequent Koipato volcanism (SILBERLING, 1973). But by Spathian time these events were over and from then until the Norian there was a purely sedimentary miogeoclinal regime.

West of the coast there was probably a sea or ocean of considerable dimensions. The extensive distribution of ultramafic rocks in and about the suspect terranes is presumably in harmony with such an interpretation. Some of the Triassic rocks of the British Columbia border zone, particularly those of the McDame area, may be deposits of such an ocean. The Teslin suture, which according to TEMPELMAN-KLUIT (1979) marks the site of a closed ocean, would also be evidence of this feature.

Farther offshore were the volcanic archipelagos, shoals, banks and intervening oceanic basins which now form the mosaic of terranes. If the Triassic rocks of the British Columbia border zone are truly associated with contemporary volcanic rocks, and are not slices off the North American plate, or pieces of an intervening ocean, they would indicate that the first offshore archipelago was at mid-paleolatitude.

Proceeding farther offshore and towards the Triassic equator there is evidence for many volcanic archipelagos with fringing coralline sediments (Quesnelia, Stikinia, Alexander, Wrangellia etc.). Adjacent to these volcanic islands were the basins and troughs that accomodated the Cache Creek, Bridge River and similar formations. The Norian sequence of Tyaughton Creek (Locality 18) may have been in an isolated situation, west of which lay the Alexander terrane and then Wrangellia. Wrangellia in the Triassic was presumably more compact than today, its present distribution being related to the dextral Cordilleran faults. Wrangellia, with more tabular carbonate formations (Quatsino, Chitistone, Nizina) than most of the suspect terranes was perhaps a Carnian Bahamas. Judging from the terrane map of Alaska provided by JONES and SILBERLING (1979) and from the occurences of suspect Triassic in Oregon, California and Baja California (RANGIN, 1978; FINCH and ABBOTT, 1977; DICKINSON, 1979), it seems certain that Wrangellia is not the westernmost of the chunks and strips that are now amalgamated in the mosaic of the Cordillera. All appear to have been at low latitude in the Triassic. All presumably formed east of the spreading ridge from which the present Pacific bottom began to form in the Jurassic.

Direct evidence for the existence of the spreading ridge within Panthalassa is not preserved. However the grabens of Greenland and Madagascar suggest that todays spreading regime began at about the time of the Permian-Triassic boundary (TOZER, 1971, p. 1006; DONOVAN, 1972). The assumption that it had also started in Panthalassa thus seems justified (Figure 2).

If, as seems probable, there were comparable islands west of the spreading ridge, one can visualize a Triassic Panthalassa with islands extending across its entire girth. These would have provided bottom dwelling faunas easier access between Tethys and the eastern shore of Panthalassa than a gigantic landless ocean. The life style of the ammonoids was probably not unlike that of living NAUTILUS, who apparently spends much time feeding near the bottom. An island studded Panthalassa would have been more congenial than an open ocean some 20 000 km wide.

A Panthalassa littered with islands seems also to be the interpretation of DICKINSON (1977, p. 151) and MONGER (1977 b, fig. 8). Monger proposed this to account for the Late Paleozoic geology; Dickinson applied it to the early Mesozoic as well.

A case can be made for placing northern New Guinea, New Caledonia and New Zealand in the northern hemisphere at about the latitude of the MPL province. This would satisfy the distribution of AMPHIPOPANOCERAS (Anisian), which is now known from New Guinea (SKWARKO, 1973) as well as New Zealand.

There is no evidence that AMPHIPOPANOCERAS reached, let alone crossed the LPL province and Tethys *). It is unknown in the Hallstatt facies despite the fact that the Anisian is well represented. For this reason it is suggested that AMPHIPOPANOCERAS characterizes the Anisian of the northern hemisphere and was not bipolar, as held by KOZUR (1973). PROCLYDONAUTILUS NATOSINI McLearn (Lower-Middle Norian, MPL-HPL) on the American Plate is probably the same as P. MANDEVILLEI (Marshall) from New Zealand (TOZER, 1971, p. 1019) and P. SEIMKANENSIS Bytschkov from Siberia. This nautiloid is unknown in the coeval deposits of the LPL province and the Tethys. A distribution like that of AMPHIPOPANOCERAS is indicated. The faunal evidence thus suggests that these islands include terranes that were north of the Triassic equator, not south. N. J. Silberling tells me that his interpretation of the Upper Norian MONOTIS species of New Caledonia and New Zealand suggests the same thing. New Zealand also has OWENITES (LPL) in the Lower Triassic. Perhaps it lay near the LPL-MPL boundary.

Alternative interpretations of Pacific palaeogeography are those of MELVILLE (1966), HUGHES (1975), NUR and BEN-AVRAHAM (1977, 1978), and SHIELDS (1979). Nur and Ben-Avraham had a single Pacifica continent of which pieces are now to be found in coastal Asia, North and South America; Melville and Hughes detached most of western North America, and attached it to Asia with an ocean in between. Shields would closely juxtapose western North America and eastern Asia without detachment. For this he requires an earth that has expanded greatly since the Triassic. None of these interpretations satisfy the Triassic evidence, in particular the occurrence of markedly different sequences in the individual terranes.

Ammonoids and nautiloids evidently swarmed around the shores of these Panthalassa islands. Many made island passages. The nautiloids included the ancestors of the sole surviving genus now living in the southwest Pacific but unable to make the crossing. Cephalopods are known to be rather intelligent animals. It's unfortunate that they are not literate with archives in which would be found the logs of voyages undertaken by their ancestors. Oh for the nautiloid sagas! Halobiid and monotid bivalves probably drifted around attached to floating sea weeds — a Sargasso sea like situation. GRUBER (1976) and GRANT-MACKIE (1980) would have them living on the sea bottom but I still maintain that their distribution and mode of occurrence (so often to the exclusion of all else) strongly supports the idea of HAYAMI (1969) that they were pseudoplanktonic.

The Triassic faunas place constraints upon where the various terranes may have been at the time, namely that most or all that are now part of North America were probably between paleolatitudes 30 S and 30 N.

The longitudinal arrangement of the islands (Figure 2) has been prompted from what is known of the post-Triassic history of the Pacific. In Jurassic time a belt about 4000 km wide formed adjacent to the Panthalassa spreading ridge; about 1000 km in the Atlantic (Geological World Atlas, Sheet 20). Both these creations could have served to drive the islands towards the American Plate. The distribu-

*) One specimen of *Amphipopanoceras* is now known from the LPL Triassic of the Star Peak Group in Nevada, in collections that include hundreds of other Anisian ammonoids (K. M. Nichols and N. J. Silberling, personal communication). In collections from the MPL province there are hundreds of *Amphipopanoceras*.

tion of Jurassic and younger molasse deposits in the Rocky Mountains and Foothills (EISBACHER et al., 1974; EISBACHER and GABRIELSE, 1975), and other lines of evidence suggest that by the end of the Jurassic the terranes had fused with one another and with the plate, although probably not at their present latitude. Accomodating the terranes as islands in a belt adjacent to the coast some 5000 km wide would satisfy the spreading data. Compared with today this would take the island belt to about Hawaii. The belt has now been compressed to a width of about 1000 km. The difference of 4000 km takes into account subduction, obduction and other kinds of crustal shortening.

In conjunction with tectonic and paleomagnetic investigations these faunal constraints could be checked and tightened. The faunas have a great potential for deciphering the history of the Pacific area in the period of uncertainty that starts when the record on the present sea floor ends, i. e. prior to the mid-Jurassic.

Acknowledgement

Preparation of a paper like this, dealing with the whole of North America, would have been impossible without the cooperation of N. J. Silberling, who for more than 25 years has generously shared his knowledge of the Triassic faunas of Alaska and the western United States and given me every opportunity to see his collections, many of which are still undescribed.

References

ARMSTRONG, J. E.: Fort St. James map-area, Cassiar and Coast Districts, British Columbia. Geol. Surv. Canada Mem. 252, 1949.

BERG, H. C.: Geology of Gravina Island, Alaska. U. S. Geol. Surv. Bull. 1373, 1973.

BURCHFIEL, B. C.: Tectonics of noncollisional regimes. The modern Andes and the Mesozoic Cordilleran orogen of the western United States. In: Continental Tectonics, Studies in Geophysics, Nat. Acad. Sci. Washington: 65—72, 1980.

BURCKHARDT, C.: Etude synthétique sur le Mésozoique mexicain. Mém. Soc. Pal. Suisse, 49 (4), 1930.

BURKE, D. B. & SILBERLING, N. J.: The Auld Land Syne Group, of Late Triassic and Jurassic (?) age, north-central Nevada. U. S. Geol. Surv. Bull. 1394 E, 1973.

CAIRNES, C. E.: Slocan mining camp, British Columbia. Geol. Surv. Canada Mem. 173, 1934.

CAMERON, B. E. B. & MONGER, J. W. H.: Middle Triassic conodonts from the Fergusson Group, northeastern Pemberton map-area, British Columbia. Geol. Surv. Canada Pap. 71—1 B: 94—96, 1971.

CHAO, KING-KOO: Lower Triassic ammonoids from western Kwangsi, China. Pal. Sinica, n. ser. B, 9, whole ser. 145, 1959.

CHURKIN, M. JR.: Western boundary of the North American continental plate in Asia. Geol. Soc. Amer. Bull. 83: 1027—1036, 1972.

— & TREXLER, J. H.: Continental plates and accreted oceanic terranes in the Arctic. In: "The Ocean Basins and Margins", A. E. M. Nairn, M. Churkin Jr. & F. G. Stehli Eds., 5, The Arctic Ocean, Plenum Press, New York & London: 1—20, 1981.

CLAPP, C. H. & SHIMER, H. W.: The Sutton Jurassic of the Vancouver Group, Vancouver Island. Proc. Boston Soc. Nat. Hist. 34 (12): 425—438, 1911.

CONEY, P. J., JONES, D. L. & MONGER, J. W. H.: Cordilleran suspect terranes. Nature, 288: 328—333, 1980.

DANNER, W. T.: Limestone resources of southwestern British Columbia. Montana Bur. Mines & Geol., Special publ. 74: 171—185, 1976.

Davis, G.A., Monger, J. W. H. & Burchfiel, B. C.: Mesozoic construction of the Cordilleran "collage", central British Columbia to central California. Pacific Coast Paleography symposium 2, Soc. Economic Paleontologists and Mineralogists, Los Angeles: 1—32, 1978.

De Cserna, G. A.: Fauna fósil de la Formación Santa Clara (Cárnico) del Estado de Sonora. Pal. Mexicana, 11 (3), 1961.

Dickinson, W. R.: Paleozoic plate tectonics and the evolution of the Cordilleran continental margin. Pacific Coast Paleogeography symposium 1, Soc. Economic Paleontologists and Mineralogists, Los Angeles: 137—155, 1977.

—: Mesozoic forearc basin in central Oregon, Geology, 7: 166—170, 1979.

Diener, C.: The Trias of the Himalayas. Mem. Geol. Surv. India, 36 (3), 1912.

Donovan, D. T.: History of the North Atlantic Ocean. Meddr. Grønland, 168 (3): 31—33, 1972.

Eisbacher, G. H., Carrigy, M. A. & Campbell, R. B.: Paleodrainage patterns and late-orogenic basins of the Canadian Cordillera. Soc. Economic Paleontologists and Mineralogists, Spec. Pap. 22: 143—166, 1974.

Eisbacher, G. H. & Gabrielse, H.: The molasse facies of the Columbian orogen. Geol. Rundschau, 64 (1): 85—100, 1975.

Fabricius, F., Friedrichsen, H. & Jacobshagen, V.: Palaotemperaturen und Palaoklima in Obertrias und Lias der Alpen. Geol. Rundschau, 59 (2): 805—826, 1970.

Finch, J. W. & Abbott, P. L.: Petrology of a Triassic marine section, Vizcaino Peninsula, Baja California Sur, Mexico. Sedimentary Geology, 19: 253—273, 1977.

Freeland, G. L. & Dietz, R. S.: Rotation history of Alaskan tectonic blocks. Tectonophysics, 18: 379—389, 1973.

Fujita, K.: Pre-Cenozoic tectonic evolution of northeast Siberia. J. Geol., 86: 159—172, 1978.

Gabb, W. M.: Descriptions of some Secondary fossils from the Pacific States. Am. J. Conchology, 5: 5—18, 1870.

Gabrielse, H.: McDame map-area, Cassiar District, British Columbia. Geol. Surv. Canada Mem. 319, 1963.

Gansser, A.: Geology of the Himalayas. Interscience, London, New York, Sydney, 1964.

Gibson, D. W.: Triassic rocks of the Rocky Mountain foothills and front ranges of northeastern British Columbia and west-central Alberta. Geol. Surv. Canada Bull. 247, 1975.

Grant-Mackie, J. A.: Mode of life and adaptive evolution in the cosmopolitan Triassic bivalve Monotis. J. Malacological Soc. Australia, 4 (4): 242—243, 1980.

Gruber, B.: Neue Ergebnisse auf dem Gebiete der Ökologie, Stratigraphie und Phylogenie der Halobien (Bivalvia). Mitt. Ges. Geol. Bergbaust. Österreich, 23: 181—198, 1976.

Hamilton, W.: Continental drift in Eastern Asia and Alaska. Tectonophysics, 4: 569, 1967.

—: The Uralides and the motion of the Russian and Siberian platforms. Geol. Soc. Amer., Bull., 81: 2553—2576, 1970.

—: Complexities of modern and ancient subduction zones. In: Continental Tectonics, Studies in Geophysics, Nat. Acad. Sci. Washington: 33—49, 1980.

Hayami, I.: Notes on Mesozoic "planktonic" bivalves. J. Geol. Soc. Japan, 75 (7): 375—385, 1969.

Hillhouse, J. W.: Paleomagnetism of the Triassic Nikolai greenstone, McCarthy quadrangle, Alaska. Canadian J. Earth Sci., 14: 2578—2592, 1977.

Hillhouse, J. W. & Grommé, C. S.: Paleomagnetism of the Triassic Hound Island volcanics, Alexander terrane, southeastern Alaska. J. Geophysical Research, 85 (B 5): 2594—2602, 1980.

HUGHES, T.: The case for the creation of the north Pacific ocean during the Mesozoic era. Palaeogeography, Palaeoclimatology, Palaeoecology, 18: 1—43, 1975.

IMLAY, R. W. & DETTERMAN, R. L.: Some Lower and Middle Jurassic beds in Puale Bay-Alinchak Bay area, Alaska Peninsula. Amer. Ass. Petrol. Geol. Bull., 61 (4): 607—611, 1977.

IRVING, E.: Drift of the major continental blocks since the Devonian. Nature, 270: 304—309, 1977.

JELETZKY, J. A.: Mesozoic and? Tertiary rocks of Quatsino Sound, Vancouver Island, British Columbia. Geol. Surv. Canada Bull. 242, 1976.

JENKYNS, H. C.: Tethys: past and present. Proc. Geologists' Ass., 91: 107—118, 1980.

JONES, D. L. & SILBERLING, N. J.: Mesozoic stratigraphy — the key to tectonic analysis of southern and central Alaska. U. S. Geol. Surv., Open-file report 79—1200, 1979.

JONES, D. L., SILBERLING, N. J., CSEJTEY, B., NELSON, W. H. & BLOME, C. D.: Age and structural significance of ophiolite and adjoining rocks in the Upper Chulitna District, south-central Alaska. U. S. Geol. Surv. Prof. Paper 1121-A, 1980.

JONES, D. L., SILBERLING, N. J. & HILLHOUSE, J. W.: Wrangellia — a displaced terrane in northwestern North America. Canadian J. Earth Sci., 14: 2565—2577, 1977.

KING, P. B.: The evolution of North America, Revised edition, Princeton University Press, 1977.

KING, R. E.: Geological reconnaissance in northern Sierra Madre Occidental of Mexico. Geol. Soc. Amer. Bull., 50: 1625—1722, 1939.

KOZUR, H.: Faunenprovinzen in der Trias und ihre Bedeutung für die Klärung der Palaographie. Geol. Palaont. Mitt. Innsbruck, 3 (8): 1—41, 1973.

KRISTAN-TOLLMANN, E. & TOLLMANN, A.: Die Stellung der Tethys in der Trias und die Herkunft ihrer Fauna. Mitt. österr. geol. Ges. 74/75: 129—135, 1981.

KUENZI, W. D.: Early Triassic (Scythian) ammonoids from northeastern Washington. J. Paleontol., 39: 365—378, 1965.

KUMMEL, B.: Ammonoids of the late Scythian (Lower Triassic). Bull. Museum Comparative Zoology, 137 (3): 311—702, 1969.

—: Lower Triassic (Scythian) molluscs. In: Atlas of palaeobiogeography, A. Hallam Ed., Elsevier, Amsterdam, London, New York: 225—233, 1973.

LEES, E. J.: Geology of the Laberge area, Yukon. Trans. Royal Canadian Inst., 20 (1): 1—48, 1934.

MCGEARY, S. E. & BEN-AVRAHAM, Z.: Allochthonous terranes in Alaska: implications for the structure and evolution of the Bering Sea shelf. Geology, 9: 608—614, 1981.

MCLEARN, F. H.: The Neo-Triassic CASSIANELLA fauna of Tyaughton Creek valley, B. C. Canadian Field-Naturalist, 56 (7): 99—103, 1942.

MELVILLE, R.: Continental drift, Mesozoic continents and the migrations of the Angiosperms. Nature, 211: 116—120, 1966.

MONGER, J. W. H.: The Triassic Takla Group in McConnell Creek map-area, north-central British Columbia. Geol. Surv. Canada Paper 76—29, 1977 a.

—: Upper Paleozoic rocks of the western Canadian Cordillera and their bearing on Cordilleran evolution. Canadian J. Earth Sci., 14: 1832—1859, 1977 b.

MONGER, J. W. H. & IRVING, E.: Northward displacement of north-central British Columbia. Nature, 285: 289—294, 1980.

MONGER, J. W. H. & PRICE, R. A.: Geodynamic evolution of the Canadian Cordillera — progress and problems. Canadian J. Earth Sci., 16: 770—791, 1979.

MONGER, J. W. H., PRICE, R. A. & TEMPELMAN-KLUIT, D.: Tectonic accretion and the origin of the two major metamorphic and plutonic welts in the Canadian Cordillera. Geology, 10: 70—75, 1982.

Monger, J. W. H. & Ross, C. A.: Distribution of fusulinaceans in the western Canadian Cordillera. Canadian J. Earth Sci., 8: 259—278, 1971.

Muffler, L. P. J.: Stratigraphy of the Keku Islets and neighbouring parts of Kuiu and Kupreanof Islands, southeastern Alaska. U. S. Geol. Surv., Bull. 1241-C, 1967.

Muller, J. E., Northcote, K. E. & Carlisle, D.: Geology and mineral deposits of Alert Bay-Cape Scott map-area, Vancouver Island, British Columbia. Geol. Surv. Canada Paper 74—8, 1974.

Muller, S. W. & Ferguson, H. G.: Mesozoic stratigraphy of the Hawthorne and Tonopah quadrangles, Nevada. Geol. Soc. Amer. Bull., 50: 1573—1624, 1939.

Nichols, K. M. & Silberling, N. J.: Stratigraphy and depositional history of the Star Peak Group (Triassic), northwestern Nevada. Geol. Soc. Amer. Special Paper 178, 1977.

— & —: Early Triassic (Smithian) ammonites of paleoequatorial affinity from the Chulitna terrane, south-central Alaska. U. S. Geol. Surv. Prof. Paper 1121-B, 1979.

Nur, A. & Ben-Avraham, Z.: Lost Pacifica continent. Nature, 270: 41—43, 1977.

— & —: Speculations on mountain building and the lost Pacific continent. J. Physics of the Earth, 26: S 21—37, 1978.

Okulitch, A. V. & Cameron, B. E. B.: Stratigraphic revisions of the Nicola, Cache Creek and Mount Ida groups, based on conodont collections from the western margin of the Shuswap metamorphic complex, south-central British Columbia. Canadian J. Earth Sci., 13: 44—53, 1976.

Orchard, M. J.: Triassic conodonts from the Cache Creek Group, Marble Canyon, southern British Columbia. Geol. Surv. Canada Paper 81—1 A: 357—359, 1981.

Oldow, J. S.: Triassic Pamlico Formation: an allochthonous sequence of volcanogenic-carbonate rocks in west-central Nevada. Pacific Coast Paleogeography symposium 2, Society of Economic Paleontologists and Mineralogists, Los Angeles: 223—235, 1978.

Panuska, B. C. & Stone, D. B.: Late Palaeozoic palaeomagnetic data for Wrangellia: resolution of the polarity ambiguity. Nature, 293: 561—563, 1981.

Patton, W. W. & Dutro, J. T.: Preliminary report on the Paleozoic and Mesozoic sedimentary sequence on St. Lawrence Island, Alaska. U. S. Geol. Surv. Prof. Paper 650-D: 138—143, 1970.

Petryk, A. A.: Mesozoic and Tertiary stratigraphy at Lake Hazen, northern Ellesmere Island. Geol. Surv. Canada Paper 68—17, 1969.

Rangin, C.: Speculative model of Mesozoic geodynamics, central Baja California to northeastern Sonora (Mexico). Pacific Coast Paleogeography symposium 2. Society of Economic Paleontologists and Mineralogists Los Angeles: 85—106, 1978

Sengor, A. M. C., Yilmaz, Y. & Ketin, I.: Remnants of a pre-Late Jurassic ocean in northern Turkey: fragments of Permian-Triassic paleotethys? Geol. Soc. Amer. Bull. 91: 599—609, 1980.

Shields, O.: Evidence for initial opening of the Pacific Ocean in the Jurassic. Palaeogeography, Palaeoclimatology, Palaeoecology, 26: 181—220, 1979.

Silberling, N. J.: "Trachyceras Zone" in the Upper Triassic of the western United States. J. Paleontol., 30: 1147—1153, 1956.

—: Stratigraphic distribution of Middle Triassic ammonites at Fossil Hill, Humboldt Range, Nevada. J. Paleontol., 36: 153—160, 1962.

—: Biostratigraphy of marine Triassic in northern Alaska. American Assoc. Petroleum Geologists Bull. 54: 2504, 1970.

—: Geologic events during Permian-Triassic time along the Pacific margin of the United States. Canadian Soc. Petrol. Geol. Mem. 4: 345—362, 1973.

Silberling, N. J. & Roberts, R. J.: Pre-Tertiary stratigraphy and structure of northwestern Nevada. Geol. Soc. Amer. Special Paper 72, 1962.

Silberling, N. J. & Tozer, E. T.: Biostratigraphic classification of the marine Triassic in North America. Geol. Soc. Amer. Special Paper 110, 1968.

Silberling, N. J. & Wallace, R. E.: Stratigraphy of the Star Peak Group (Triassic) and overlying lower Mesozoic rocks Humboldt Range, Nevada, U. S. Geol. Surv. Prof. Paper 592, 1969.

SKWARKO, S. K.: Middle and Upper Triassic mollusca from Yuat River, eastern New Guinea. Bureau Mineral Resources, Geol. & Geophysics, Canberra, Bull. 126: 27—50, 1973.

SMITH, J. P.: Upper Triassic marine invertebrate faunas of North America. U. S. Geol. Surv. Prof. Paper 141, 1927.

—: Lower Triassic ammonoids of North America. U. S. Geol. Surv., Prof. Paper 167, 1932.

SOUTHER, J. G.: Volcanism and tectonic environments in the Canadian Cordillera — a second look. Geol. Ass. Canada Special Paper 16: 3—24, 1977.

SPEED, R. C.: Collided Paleozoic microplate in the western United States. J. Geol., 87: 279—292, 1979.

STANLEY, G. D.: Paleoecology, structure and distribution of Triassic coral buildups in western North America. Univ. Kansas Paleont. Contribution 5, 1979.

—: Early history of scleractinian corals and its geological consequences. Geology, 9: 507—511, 1981.

STAUBER, H.: Die Triasablagerungen von Ostgrönland. Meddr. Grønland, 132 (1), 1942.

STOCKLIN, J.: Geology of Nepal and its regional frame. J. Geol. Soc. London, 137: 1—34, 1980.

STONELEY, R.: A note on the structural evolution of Alaska. J. Geol. Soc. London, 127: 623—628, 1971.

SURDAM, R. C., SUSUKI, T. & CARLISLE, D.: Upper Triassic section on Iron River, Vancouver Island, British Columbia. Geol. Soc. Amer. Special Paper 76: 226, 1964.

SUTHERLAND BROWN, A.: Geology of the Queen Charlotte Islands, British Columbia. British Columbia Dept. Mines Petrol. Resources Bulletin 54, 1968.

TATZREITER, F.: Ammonitenfauna und Stratigraphie im hoheren Nor (Alaun, Trias) der Tethys aufgrund neuer Untersuchungen in Timor. Denkschr. Österr. Akad. Wiss. Math.-Naturwiss. Kl. 121, 1981.

TEMPELMAN-KLUIT, D.: Stratigraphy and structure of the "Keno Hill quartzite" in the Tombstone River-Upper Klondike River map-areas, Yukon Territory (116 B/7, B/8). Geol. Surv. Canada Bull. 180, 1970.

—: Transported cataclasite, ophiolite and granodiorite in Yukon: evidence of arc-continent collision. Geol. Surv. Canada Paper 74—14, 1979.

THORSTEINSSON, R. & TOZER, E. T.: Geology of the Arctic Archipelago. Geol. Surv. Canada, Economic Geol. Report 1 (Fifth ed.): 547—590, 1970.

TIPPER, H. W.: Geology, Prince George, Cariboo District, British Columbia. Geol. Surv. Canada, Map 49—1960, 1961.

—: Offset of an upper Pliensbachian geographic zonation in the North American Cordillera by transcurrent movement. Canadian J. Earth Sci., 18: 1788—1792, 1981.

TOZER, E. T.: Stratigraphy of the Lewes River Group (Triassic), central Laberge area, Yukon Territory. Geol. Surv. Canada, Bull. 43, 1958.

—: Triassic stratigraphy and faunas, Queen Elizabeth Islands, Arctic Archipelago. Geol. Surv. Canada, Mem. 316, 1961.

—: A standard for Triassic time. Geol. Surv. Canada, Bull. 156, 1967.

—: Marine Triassic faunas. Geol. Surv. Canada, Economic Geol. Report 1 (Fifth edition): 633—640, 1970.

—: Triassic time and ammonoids: problems and proposals. Canadian J. Earth Sci., 8: 989—1031, 1971.

—: Review of the Lower Triassic ammonoid succession and its bearing on chronostratigraphic nomenclature. Österr. Akad. Wiss., Schrift. Erdwissenschaftlichen Komm. 4: 21—36, 1978.

—: Latest Triassic (Upper Norian) ammonoid and Monotis faunas and correlations. Riv. Ital. Paleont. 85 (3—4): 843—876, 1980.

—: Triassic Ammonoidea: geographic and stratigraphic distribution. In: "The Ammonoidea", M. R. House & J. R. Senior Editors, Systematics Association Special vol. 18: 397—431, 1981.

Tozer, E. T. & Thorsteinsson, R.: Western Queen Elizabeth Islands, Arctic Archipelago. Geol. Surv. Canada Mem. 332, 1964.

Travers, W. B.: Overturned Nicola and Ashcroft strata and their relation to the Cache Creek Group, southwestern intermontane belt, British Columbia. Canadian J. Earth Sci., 15: 99—116, 1978.

Trettin, H. P.: Permian rocks of the Cache Creek Group in the Marble Range, Clinton area, British Columbia Geol. Surv. Canada Paper 79—17, 1980.

Trümpy, R.: Triassic of East Greenland. In G. O. Raasch, Ed., Geology of the Arctic, 1, University of Toronto Press: 248—254, 1961.

Vereshchagin, V. N. & Ronov, A. B. (Editors): Atlas of the lithological — paleogeographical maps of the U. S. S. R., 3, Triassic, Jurassic & Cretaceous. Ministry of Geol. & Acad. Sci. U. S. S. R., 1968.

Wang Yi-Gang, Chen Chu-Chen, He Guo-Xiong & Chen Jin-Hua: An outline of the marine Triassic in China. I. U. G. S. Publication 7, 1981.

Wardlaw, B. R. & Jones, D. L.: Triassic conodonts from eugeoclinal rocks of western North America and their tectonic significance. Riv. Ital. Paleont. 85 (3—4): 895—908, 1980.

Westermann, G. E. G.: The late Triassic bivalve Monotis. In: "Atlas of Palaeobiogeography", A. Hallam Editor, Elsevier, Amsterdam, London, New York: 251—258, 1973.

Whetten, J. T., Jones, D. L., Cowan, D. S. & Zartman, R. E.: Ages of Mesozoic terranes in the San Juan Islands, Washington. Pacific Coast Paleogeography Symposium 2. Society of Economic Paleontologists and Mineralogists, Los Angeles: 117—132, 1978.

Yancey, T. E.: Permian positions of the northern hemisphere continents as determined from marine biotic provinces. In: "Historical Biogeography, Plate Tectonics and the Changing Environment", Jane Gray and A. J. Boucot Editors, Oregon State University Press: 239—247, 1979.

Yole, R. W. & Irving, E.: Displacement of Vancouver Island: paleomagnetic evidence from the Karmutsen Formation. Canadian J. Earth Sci., 17: 1210—1228, 1980.

Zacharov, Yu. D.: The importance of palaeobiogeographical data for the solution of the problem of the Lower Triassic division. Österr. Akad. Wiss. Schrift. Erdwissenschaftlichen Komm., 2: 237—243, 1974.

Zacharov, Yu. D., Naidin, D. P. & Teiss, R. V.: Oxygen isotopic composition of the Lower Triassic cephalopod shells from Arctic Siberia and salinity of boreal basins in early Mesozoic. Proc. U. S. S. R. Acad. Sci. Geol. ser. 4 (1975): 101—113, 1975 (In Russian).