Restricted until after publication.
Manuscript submitted for publication
to: J. Geol. Soc. Aust.

DEPARTMENT OF
MINERALS AND ENERGY

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record 1973/160

THE AGE OF THE KOCKATEA SHALE (LOWER TRIASSIC), PERTH BASIN - A REASSESSMENT

by

R.A. McTavish and J.M. Dickins

1973/160

THE AGE OF THE KOCKATEA SHALE (LOWER TRIASSIC), PERTH BASIN - A REASSESSMENT

by

R.A. McTavish & J.M. Dickins[1]

ABSTRACT

New evidence for the age of *Subinyoites kashmiricus*, combined with that of *Claraia stachei* and *Discophiceras* sp. cf. *D. subkyokticum*, has called for a revision in age of the Scythian (Lower Triassic) macrofauna from the Kockatea Shale of Beagle Ridge (BMR 10) Bore. The fauna is now regarded as of Scythian (Griesbachian to Smithian) age. Combination of this dating with additional palaeontological evidence from the Perth and Carnarvon Basins: (i) indicates that the base of the Kockatea Shale is markedly different in age in Beagle Ridge (BMR No. 10) Bore, Dongara No. 4 and in outcrop at Mount Minchin and Sugarloaf Hill; (ii) suggests that the Lower Triassic sea was most extensive during the Smithian in the Perth Basin; and (iii) confirms that most of the Locker Shale is younger than the Kockatea Shale.

[1] Published with the permission of the Director, Bureau of Mineral Resources, Canberra.

INTRODUCTION

Marine Triassic macrofossils in Australia were first recorded by Dickins, McTavish, & Balme (1961). They were collected from cores taken between 733 and 979 m in the Kockatea Shale of Beagle Ridge (BMR 10) Bore (Fig. 1). When this small collection of invertebrate macrofossils was described in more detail (Dickins & McTavish, 1963) it was referred to the Otoceratan (Lower Scythian) (Table I, which is based on Table II of Tozer (1965), and compares stratigraphical subdivisions of the Lower Triassic used in this paper). Skwarko & Kummel (in press) have expressed some doubt about the age of the fauna from the Beagle Ridge (BMR 10) Bore.

Glenister & Furnish (1961, p. 689) recorded an ophiceratid ammonoid with a small conodont fauna and rich microflora from 448 m in the Geraldton Racecourse Bore and regarded it as Dzhulfian or early Scythian in age. Palynological evidence (Balme, 1963) from a sample 1.5 m above the ammonoid suggests that it is of Early Triassic age.

Shortly after the Beagle Ridge fauna was described, Edgell (1964) reported on a collection of ammonoid impressions from the outcrop of the Minchin Siltstone (= Kockatea Shale, according to McWhae, Playford, Lindner, Glenister, & Balme, 1958) at Mount Minchin in the northernmost part of the Perth Basin and proposed an Owenitan age for the collection. This dating of Kockatea Shale was not accepted as readily as that of Dickins & McTavish (1963) by Balme (1969a, 1969b). However, the identification by Professor B. Kummel of Anasibirites in a better-preserved collection of ammonites, dated as Owenitan, from the Kockatea Shale of the same area (Karajas, 1969; Skwarko & Kummel, in press) supports Edgell's age estimate.

Conodonts recently recovered from an ammonoid-bearing core (Core 1, 1661-1669 m, Dongara No. 4) have been dated as Dienerian (McTavish, in press). On the basis of ammonites, Skwarko & Kummel (in press) suggest correlation of Core 1 with the 'Ceratite Marl' of the Salt Range, and Core 2 (1669-1677.5 m) with the 'Lower Ceratite Limestone', indicating a similar age to the conodonts.

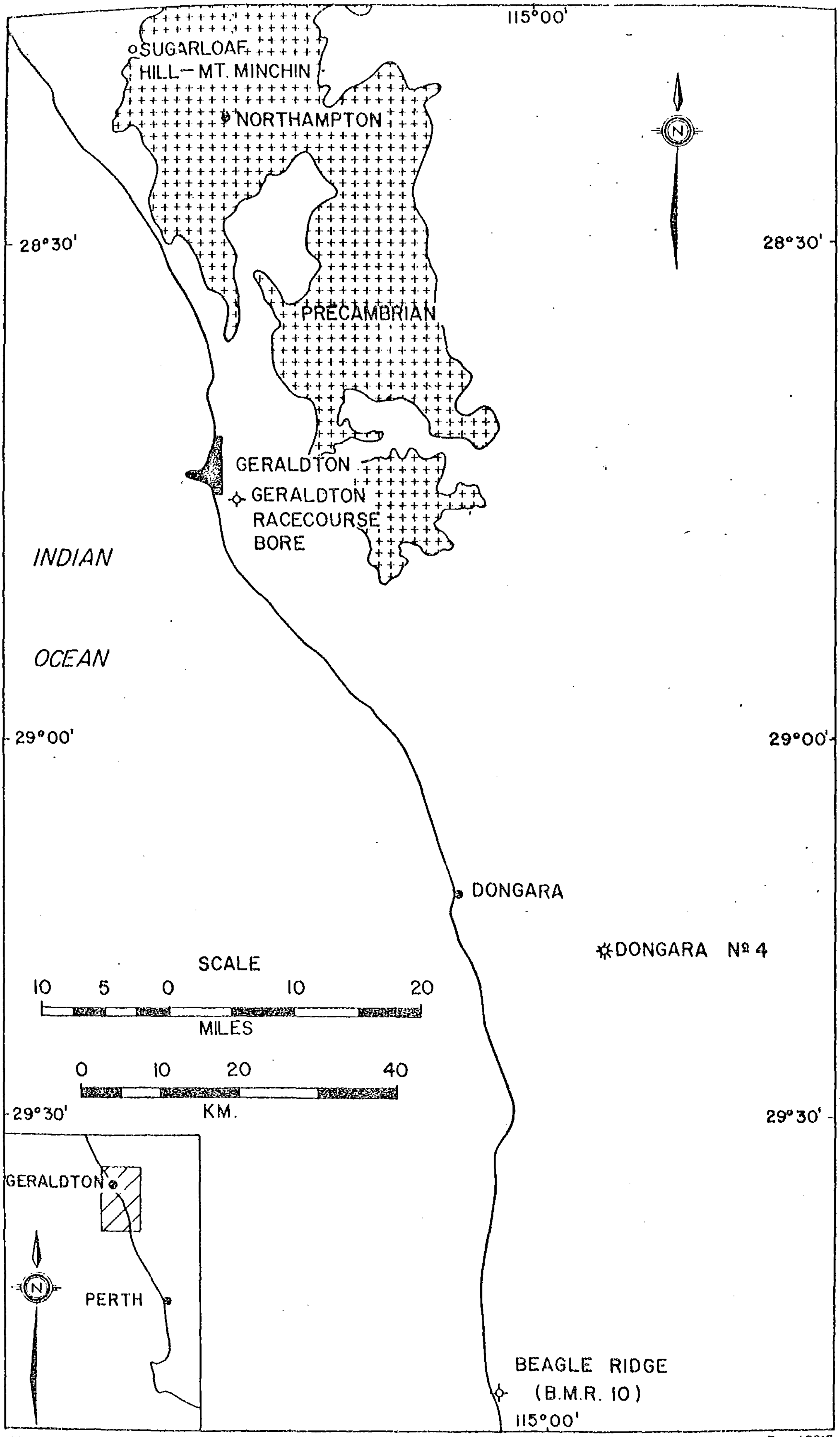


FIGURE 1 Map of northern Perth Basin showing positions of Beagle Ridge (BMR 10) Bore, Dongara No. 4, Geraldton Racecourse Bore, and the Sugarloaf Hill Mt. Minchin surface locality.

B -40215

To accompany Record 1973/160

H50/A1/2

Table I. Correlation of Subdivisions of Lower Triassic Series used in this paper. (Based on Tozer, 1965, table II).

TOZER		SPATH
SERIES	STAGES	DIVISIONS
LOWER TRIASSIC	Spathian	Prohungaritan
		Columbitan
	Smithian	Owenitan
	Dienerian	Flemingitan
	Dienerian / Griesbachian	Gyronitan
	Griesbachian	Otoceratan

In recent years several works bearing on the dating of the Kockatea Shale by its invertebrate macrofauna have appeared. This paper applies the results of these works to the dating of the Kockatea Shale, especially as it is represented in the Beagle Ridge (BMR 10) Bore, and considers briefly the palaeogeographical implications of the new age interpretations.

As sequences of late Permian and early Triassic age are nonmarine in most parts of Australia, the description of early Triassic marine invertebrates and plant micro-fossils (Balme 1963) in the same section of Kockatea Shale, and the age of the Kockatea Shale, have become important for relating late Permian and early Triassic sequences in Australia to those from other parts of the world.

THE INVERTEBRATE MACROFAUNA OF BEAGLE RIDGE (BMR 10) BORE

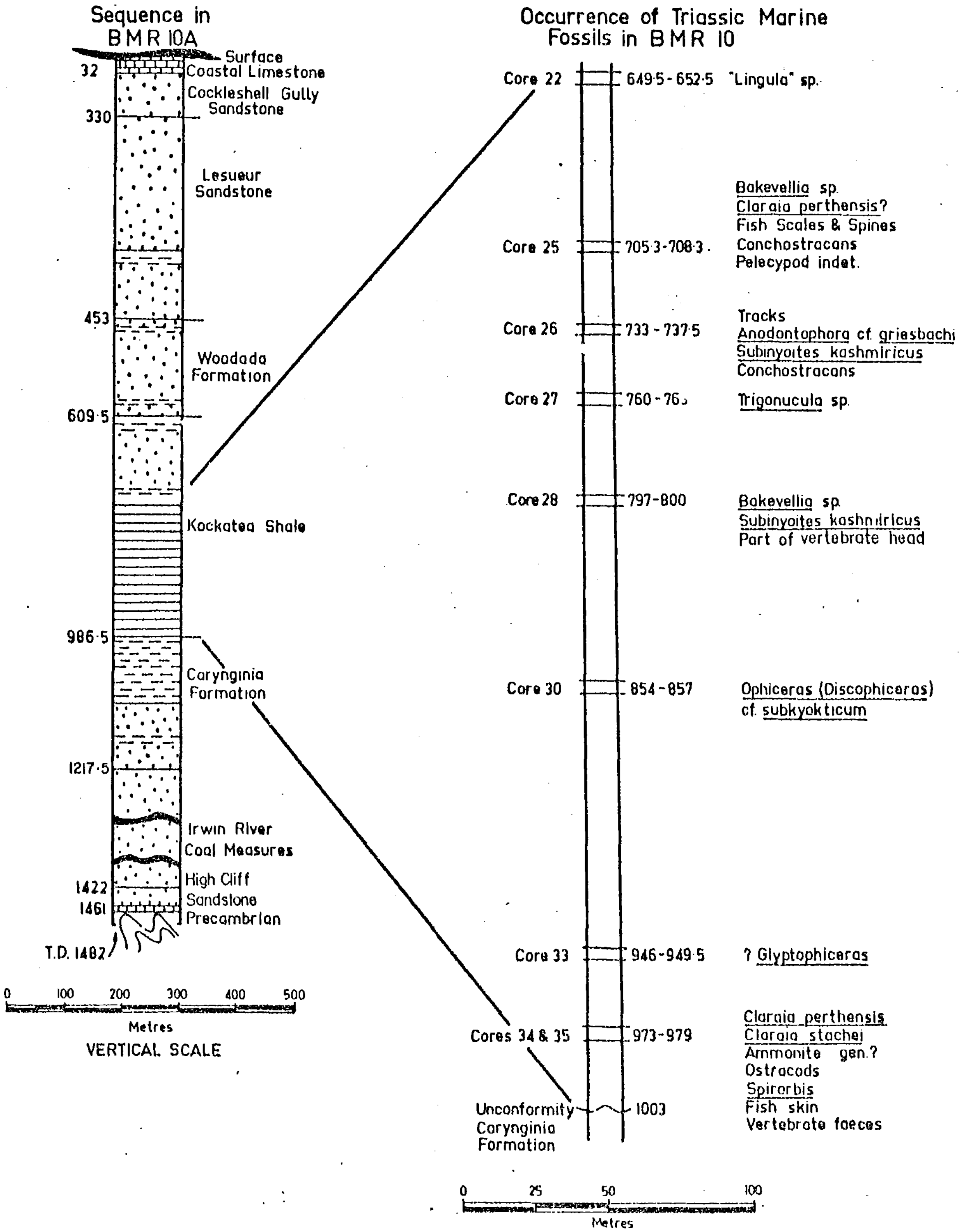
The Lower Triassic invertebrate macrofauna from Beagle Ridge (BMR 10) Bore was described by Dickins & McTavish (1963). Rare specimens referred to some of the taxa described have been found in cores from the Triassic of some deep wells drilled subsequently in the northern part of the Perth Basin.

For the purposes of this paper the identifications by Dickins & McTavish (1963) have been accepted as still valid. Although the species identified occur elsewhere than the Beagle Ridge (BMR 10) Bore in the Perth Basin, their presence in this well (recorded on Fig. 2) provides an adequate basis for discussion.

The most important species for age determination in the Beagle Ridge (BMR 10) Triassic fauna are *Ophiceras* (*Discophiceras*) sp. cf. *O.* (*D.*) *subkyokticum* (Spath), *Subinyoites kashmiricus* (Diener), and *Claraia stachei* Bittner. The biostratigraphical implications of these species will be discussed below.

Fig. 2

FIGURE 2. Section encountered in Beagle Ridge (BMR 10A) Bore and the distribution of Triassic macrofauna in Beagle Ridge (BMR 10) Bore (Modified from Dickens & McTavish 1963, fig. 2).



To accompany Record 1973/160

B-40605 M.S12

RANGES OF KEY SPECIES

Claraia stachei Bittner

The range of *Claraia stachei* Bittner has been considered previously by several authors (e.g. Tozer 1967, 1969, 1971; Silberling & Tozer 1968; Nakazawa *et al.*, 1970). Unequivocal records of the species indicate that it is of Griesbachian age. However, Silberling (1972, pers. comm.) reported that *C. stachei* occurs at one locality in Nevada both below and with ammonites that he '... would have to call lower Dienerian'. Tozer (1971, p. 1015), on the other hand, has suggested that the upper Dienerian record of *C. stachei* by Vavilov (1968) is due to incorrect identification of a species '... related to '*Pseudomonotis*' *venetiana* (Hauer)', which occurs in the upper Dienerian of Ellesmere Land. The reported range of *C. stachei* as high as the Smithian *Meekoceras gracilitatis* Zone in southeastern Idaho (Ciriacks, 1963) '... requires further verification' according to Silberling & Tozer (1968).

The occurrence of *Claraia stachei* in the Guryul Ravine section described by Teichert, Kummel, & Kapoor (1970) and Nakazawa *et al.* (1970) is critical to the interpretation of the lower limit of the range of *C. stachei*. Tozer (1971, 1972) has suggested that, in this section, *C. stachei* might extend into the Permian or the identification of *C. stachei* might be incorrect. The stratigraphical interpretation of the Guryul Ravine section by Nakazawa *et al.* (1970) is not in conflict with correct identification of *Claraia stachei* and its previously established range. *Claraia stachei* ranges from Bed 48 to Bed 52. Permian fossils have been found with *C. stachei* through its range in this section. This association was interpreted as a mixed Permian-Early Triassic fauna by Nakazawa *et al.* (1970) and Teichert *et al.* (1970). The Permian species were considered in both papers to be Permian 'survivors' rather than specimens reworked into the Triassic. However, the imperfect preservation of the Permian species figured by

Nakazawa et al. (1970) is not inconsistent with possible reworking. The lowest occurrence of Otoceras is in Bed 52, and Tozer (1971) took this bed to mark the base of the Triassic in the Guryul Ravine section. Thus, underlying beds, in which Claraia stachei was the dominant species (Beds 48-51), were referred to the Permian.

Lithological evidence has an important role in the interpretation of the biostratigraphy of the Guryul Ravine section. The unit of contention, which comprises Beds 47-51, is much closer lithologically, and therefore genetically, to the Lower Triassic sequence, and Beds 63-69 in particular, than to any part of the Zewan Series as figured by Nakazawa et al. (1970), Teichert et al. (1970), Sweet (1970), and Kapoor (1972). Nakazawa et al. (1970, p. 165) considered that the sequence was conformable and there was no sign of a hiatus. However, the marked change in lithological character from Bed 46b of the Upper Permian Zewan Series to the basal unit of the Lower Triassic beds (Beds 47-51) and the sandy nature of the shales of the Lower Triassic unit are not inconsistent with a stratigraphic discontinuity at the Permian-Triassic boundary. Kummel & Teichert (1970) interpreted the Permian-Triassic contact of the Salt Range and Trans-Indus Ranges similarly when they suggested that the contact was a paraconformity representing a gap of a stage or more.

Environmental factors may have delayed the entry of species of Otoceras in the Guryul Ravine section, where representatives of Otoceras were found only in the Lower Triassic unit contained by Beds 52-60. This unit, about 8 m thick, consists of flaggy shale and minor intercalated thin beds of limestone, with a bed of limestone, 60 cm thick, at the top. The ranges of Claraia stachei and Claraia spp. ind. span the lower and upper boundaries respectively of this unit. As it is only near the boundaries of the unit of flaggy shale (Beds 52-60) that species of Claraia and Otoceras were found together in Guryul Ravine, it can be inferred that representatives of Claraia and Otoceras tended to be mutually exclusive except at their boundary of common environmental tolerance.

In their comparison of Otoceras clivei with O. concavum, which is the index species for the lowermost ammonoid zone of the Lower Triassic of Canada (Tozer 1967), Nakazawa et al. (1970) considered, with good reason, that O. clivei was the more advanced species and occurred (p. 167) '... at a nearly equivalent level to O. boreale or O. woodwardi'. If the influence of environmental tolerances of Claraia and Otoceras expressed in the preceding paragraph and the biostratigraphical interpretations evoked for Otoceras clivei are correct, then Otoceras concavum or a closely similar species of Otoceras could be expected in beds equivalent to Beds 47-51 of the Guryul Ravine section deposited in a more favourable environment.

In summary, a Griesbachian and, probably, basal Dienerian range seems most likely for Claraia stachei. Age interpretations for Claraia stachei outside this range may be due to errors of identification or of stratigraphical interpretation.

Ophiceras (Discophiceras) sp. cf. O. (D.) subkyokticum (Spath)

Tozer (1971) has interpreted a Griesbachian to Dienerian range for Discophiceras. More precise documentation by Tozer (1967) indicates that species of Discophiceras range from the upper Griesbachian Ophiceras commune Zone to the Proptychites candidus Zone of the lower part of the Dienerian.

The first description of Ophiceras (Discophiceras) subkyokticum by Spath (1935) was based on material from the upper Ophiceras beds of East Greenland. These beds have been selected by Tozer (1967, p. 16; see also Silberling & Tozer, 1968) to be the stratotype of the Ophiceras commune Zone, which has been dated consistently (Tozer 1967, 1971; Silberling & Tozer 1968) as upper Griesbachian. Ophiceras (Discophiceras) subkyokticum has been recorded (Newell & Kummel, 1941, 1942, Kummel, 1954) also from the lower part of the Dinwoody Formation of Idaho, Wyoming, and Montana, USA. Kummel (1954) remarked on the similarity of the ammonoid faunas from the lower Dinwoody Formation, which contains _O._ (_Discophiceras_) _subkyokticum_, and the '_Ophiceras_' beds of East Greenland. Silberling & Tozer (1968) dated the lower Dinwoody Formation as upper Griesbachian.

Subinyoites kashmiricus (Diener)

When _S. kashmiricus_ was first described from the Perth Basin (Dickins & McTavish, 1963) its occurrence in cores 26 (733-736 m) and 28 (797-800 m) of Beagle Ridge (BMR 10) Bore was dated as Otoceratan. This dating was based on Diener's (1913) interpretation of the age and stratigraphical position of the loose blocks which form the type locality of _S. kashmiricus_ in the Pastannah area of Kashmir. Bion (1914) was the first to suggest that Diener's interpretation of the stratigraphic position of the Pastannah or '_Ophiceras_' fauna, as the collection which contained _S. kashmiricus_ has come to be known, was incorrect.

Kummel (1970), on a brief visit in 1968, tried to determine the precise stratigraphical position of the '_Ophiceras_' fauna, but he was unsuccessful because of the dense vegetation and poor outcrop of the Pastannah area. He concluded (Kummel, 1970, p. 181): 'If the Pastannah fauna is not exactly synchronous with the _Ophiceras_ beds of Spiti, it appears to be a transitional fauna to the next higher zone'.

At about the same time, Tozer (1969, 1971) was proposing a Smithian age for the Pastannah fauna on the basis of his interpretation of the ammonoid collection and the recognition of a left valve of '_Pseudomonotis_' _himaica_ Bittner attached to a specimen of '_Ophiceras ptychodes_ Diener' in the collection.

Recent detailed mapping of the Pastannah (= Pastun), Kashmir area (Kapoor m.s., 1972) indicates that the stratigraphical position of the '_Ophiceras_' fauna appears to be the same as that of the _Meekoceras_ Zone of the Guryul Ravine.

Table II. Occurrence and age of key invertebrate species of the Kockatea Shale of Beagle Ridge (BMR 10) Bore.

SPECIES	OCCURRENCE	AGE
Subinyoites kashmiricus (Diener)	Core 26 (733-736 m) Core 28 (797-800 m)	Smithian
Ophiceras (*Discophiceras*) sp. cf. *O.* (*D.*) *subkyokticum* (Spath)	Core 30 (854-857 m)	upper Griesbachian
Claraia stachei Bittner	Cores 34 and 35 (973-979.5 m)	lower Griesbachian

Additional evidence indicative of the age of S. kashmiricus comes from Afghanistan. Kummel & Erben (1968, p. 113, Pl. 20, Figs. 16, 17) identified an imperfectly preserved ammonoid from the Smithian (= Owenites zone) of Afghanistan as Subinyoites cf. kashmiricus.

On the basis of the record from Afghanistan and the determination of the age and stratigraphical position of the 'Ophiceras' fauna of Pastannah, a Smithian age seems most likely for Subinyoites kashmiricus.

SUMMARY OF DATING

The Lower Triassic Kockatea Shale was penetrated from 610 m to 1006 m in Beagle Ridge (BMR 10) Bore (McTavish, 1965). The key species discussed were recovered from the lower 270 m of the Kockatea Shale. The precise positions of the key fossils in Beagle Ridge (BMR 10) Bore and their age indications are listed in Table II, which shows that the lower 270 m of Kockatea Shale in Beagle Ridge (BMR 10) Bore ranges in age from Griesbachian to Smithian.

The lower Griesbachian age for Cores 34 and 35 is favoured on the basis of the stratigraphical position of Claraia stachei relative to the base of the Kockatea Shale and to the occurrence of O. (Discophiceras) sp. cf. O. (D.) subkyokticum.

The upper 125 m of the Kockatea Shale, above core 26, in Beagle Ridge (BMR 10) Bore has not been precisely dated. Balme (1969b) has placed the upper boundary of the Kockatea Shale at the Smithian/Spathian boundary, but with some reservation. In view of the dating of core 26 as Smithian, the apparent rate of deposition of the Kockatea Shale in Beagle Ridge (BMR 10) Bore, and the thickness of Kockatea Shale above core 26, the age of the Kockatea Shale may extend into the Spathian.

PALAEOGEOGRAPHICAL AND STRATIGRAPHICAL RESULTS

(i) Comparison of evidence from the Beagle Ridge (BMR 10) Bore, Dongara No. 4, and outcrop at the Mount Minchin-Sugarloaf Hill locality seems to indicate that the base of the Kockatea Shale, as currently recognized, is of markedly different age at each locality.

A Griesbachian, probably lower Griesbachian, age has been demonstrated for the lowermost cores (cores 34 and 35) in the Kockatea Shale of Beagle Ridge (BMR 10) Bore. These cores were taken between about 25 and 30 m above the base of the Kockatea Shale (see Dickins & McTavish, 1963). Core 30, about 150 m above the base, was dated (Table II) as upper Griesbachian.

A conodont fauna from 1719-1719.5 m, in ammonoid-bearing Core 1, Dongara No. 4, has been dated as Dienerian (McTavish, in press). It was collected about 20 m above the base of the Kockatea Shale in Dongara No. 4.

Karajas (1969) collected an ammonoid fauna from the Kockatea Shale of the Mount Minchin-Sugarloaf Hill outcrop area about 180 km north-north-west of Beagle Ridge (BMR 10) Bore. Kummel (in Karajas, 1969) identified Anasibirites in the collection, which he dated as Owenitan (= Smithian of Table I). The dating confirms that of Edgell (1964) for his collection of ammonoids from the Mount Minchin locality. Karajas (1969) indicated that the ammonoids of the Mount Minchin-Sugarloaf Hill locality are most abundant in Unit D and occur sporadically through Unit E of the Kockatea Shale; Unit D, a bed about 1 m thick, is about 5-6 m above the base of the Triassic section.

(ii) The combination of palaeontological evidence from the Kockatea Shale of Beagle Ridge (BMR 10) Bore, Dongara No. 4, and outcrop in the Mount Minchin - Sugarloaf Hill area strongly suggests that the Lower Tirassic sea was most extensive in the Smithian in the Perth Basin.

Kockatea Shale persists for about 125 m above Core 26, the uppermost ammonoid-bearing core in the Kockatea Shale of the Beagle Ridge (BMR 10) Bore, but lithological, palaeontological, and stratigraphical evidence (Dickins & McTavish 1963; Balme, 1963; McTavish 1965) collectively indicates that in the area of the Beagle Ridge (BMR 10) Bore the Lower Triassic transgression persisted from the Griesbachian to the Smithian. The deposits of the Kockatea Shale above Core 26 can be interpreted as deposits of the initial stage of a regression which began in the Smithian, probably late Smithian, and led to the accumulation of Middle and Upper Triassic continental sediments in the Perth Basin.

Conodont evidence from the Lower Triassic of the Carnarvon Basin (McTavish, in press) similarly records that the Lower Triassic transgression was at its maximum in the Smithian. However, the transgression appears to have begun in the Dienerian in the Carnarvon Basin and to have persisted into the Spathian or possibly early Anisian. Differences in the duration of the Lower Triassic transgression in the Perth and Carnarvon Basins may depend greatly on the relative positions of the sections investigated, and on local tectonic history during deposition.

Kummel & Steele (1962, p. 641) claimed: 'of all the Scythian ammonoid zones, that of Meekoceras gracilitatus or its equivalents are most widely represented'. Silberling & Tozer (1968, pl. I), who have interpreted the Meekoceras gracilitatus Zone as Smithian, considered the Anasibirites beds as younger than the M. gracilitatus Zone, and added (p. 30): '... but they are regarded as not yet adequately differentiated from it either faunally or stratigraphically to qualify as a distinct zone'.

Kummel & Steele's (1962) observation, quoted above, suggests most strongly that, worldwide, Lower Triassic seas were most extensive in the Smithian. The Western Australian evidence of Lower Triassic transgression is consistent with this inference. Additional Australian support is provided by a Lower Triassic ammonoid fauna from the Traveston Formation, Woondum, Queensland, which has been referred to the Meekoceras gracilitatus Zone by Runnegar (1969). This is the only precisely dated Triassic ammonoid fauna found to date in eastern Australia, but Runnegar (1969, p. 819) believes that a poorly preserved ammonoid found with marine bivalves in the Brooweena Formation of the Gympie Basin, Queensland, appears to be more or less contemporaneous and possibly related to the same transgression in the Gympie Basin.

(iii) Balme (1969a) suggested that the Locker Shale of the Carnarvon Basin was 'in the main' younger than the Kockatea Shale, and added (p. 70): 'This implies that strata correlating with the lower Scythian are missing in the Onslow and Exmouth basins'. New palaeontological evidence supports Balme's interpretations and permits a more precise age comparison of the Lower Triassic sections of the Perth and Carnarvon Basins; the Onslow and Exmouth Basins of Balme (1969a) are parts of the Carnarvon Basin.

Although direct correlation of the Early Triassic faunas of the Perth and Carnarvon Basins is limited at present to the Dienerian conodonts (see McTavish, in press) the ability to refer both the molluscan fauna of the Perth Basin and the conodont fauna of the Carnarvon Basin to a common international scale for the Early Triassic has made fairly precise regional correlation of Lower Triassic strata possible. In this paper, the Kockatea Shale is regarded as Griesbachian to Smithian in age, but it may extend into the Spathian.

Complete sequences of the Locker Shale have been penetrated rarely. In one of these, the type section of the Locker Shale in Onslow No. 1 (1603-2088 m), a small conodont fauna of Smithian age is present (McTavish, in press) in a sample of ditch cuttings from the basal 15 m of the Locker Shale. Additional stratigraphical evidence and correlation of conodont faunas (McTavish, in press) from sections in which the upper part of the Locker Shale is missing strongly suggest that the greater part of the Locker Shale is of Spathian or younger age.

No evidence for a pre-Dienerian age of any Locker Shale is available. In contrast, a Griesbachian age can be demonstrated for the basal 150 m of Beagle Ridge (BMR 10) Bore. Although new palaeontological evidence supports Balme's (1969a) inference that Lower Scythian strata are missing in the northern part of the Carnarvon Basin, the possibility remains that beds of this age exist in parts of the Carnarvon Basin which were topographically lower during the Triassic than areas in which the Lower Triassic has been penetrated to date.

ACKNOWLEDGEMENTS

We are grateful to Dr H.M. Kapoor and Professor B. Kummel & Dr S.K. Skwarko for permission to cite their unpublished manuscripts. Drs N.J. Silberling and E.T. Tozer kindly provided biostratigraphical information on Lower Triassic ammonoids and bivalves.

REFERENCES

BALME, B.E., 1963 - Plant microfossils from the Lower Triassic of Western Australia. Palaeontology, 6, pp. 12-40.

BALME, B.E., 1969a - The Triassic System in Western Australia. APEA J., 9(II), pp. 67-78.

BALME, B.E., 1969b - The Permian-Triassic boundary in Australia. Geol. Soc. Aust. spec. Publ. 2, pp. 99-112.

BION, H.S., 1914 - Tract north of Srinagar and Pahlgam. Rec. geol. Surv. India, 44, pp. 39-40.

CIRIACKS, K.W., 1963 - Permian and Eotriassic bivalves of the Middle Rockies. Amer. Mus. Nat. Hist. Bull. 125, pp. 1-100.

DICKINS, J.M., & McTAVISH, R.A., 1963 - Lower Triassic marine fossils from the Beagle Ridge (BMR 10) Bore, Perth Basin, Western Australia. J. geol. Soc. Aust. 10, pp. 123-140.

DICKINS, J.M., McTAVISH, R.A., & BALME, B.E., 1961 - The Beagle Ridge Bore. Aust. Oil Gas J., 7(4), pp. 20-21.

DIENER, C., 1913 - Triassic fauna of Kashmir. Palaeont. India, N.S. 5(1).

EDGELL, H.S., 1964 - Triassic ammonite impressions from the type section of the Minchin Siltstone, Perth Basin. Dep. Min. W. Aust. ann. Rep. 1963, pp. 55-57.

GLENISTER, B.F., & FURNISH, W.M., 1961 - The Permian ammonoids of Australia. J. Paleont., 35, pp. 673-736.

KAPOOR, H.M., 1972 - Permian and Lower Trias of Pastun, Kashmir. (MS).

KARAJAS, J., 1969 - A geological investigation of an area between Mount Minchin and the Bowes River, Northampton District, Western Australia. Thesis Univ. W. Aust. (unpubl.).

KUMMEL, B., 1954 - Triassic stratigraphy of southeastern Idaho and adjacent areas. U.S. geol. Surv. prof. Pap. 254H, pp. 165-194.

KUMMEL, B., 1970 - Ammonoids from the Kathwai Member, Mianwali Formation, Salt Range, West Pakistan: In Kummel B., & Teichert, C., Eds. Stratigraphic Boundary Problems: Permian and Triassic of West Pakistan. Dep. Geol. Univ. Kansas spec. Publ. 4, pp. 177-192.

KUMMEL, B., & ERBEN, H.K., 1968 - Lower and Middle Triassic cephalopods from Afghanistan. Palaeontographica, A., 129, pp. 95-148.

KUMMEL, B., & STEELE, G., 1962 - Ammonites from the Meekoceras gracilitatus Zone at Crittenden Spring, Elko County, Nevada. J. Paleont., 36, pp. 638-703.

KUMMEL, B., & TEICHERT, C., 1970 - Stratigraphy and paleontology of the Permian-Triassic boundary beds, Salt Range and Trans-Indus ranges, West Pakistan: in Kummel, B., & Teichert, C., Eds. Stratigraphic Boundary Problems: Permian and Triassic of West Pakistan. Dep. Geol. Univ. Kansas spec. Publ., 4, pp. 1-110.

McTAVISH, R.A., 1965 - Completion Report BMR 10 and 10A, Beagle Ridge, Western Australia. Bur. Miner. Resour. Aust. Rep. 80.

McTAVISH, R.A. (in press) - Triassic conodont faunas from Western Australia. N. Jb. Geol. Palaont.

McWHAE, J.R.H., PLAYFORD, P.E., LINDNER, A.W., GLENISTER, B.R., & BALME, B.E., 1958 - The stratigraphy of Western Australia. J. geol. Soc. Aust., 4(2).

NAKAZAWA, K., KAPOOR, H.M., ISHII, K., BANDO, Y., MAEGOYA, T., SHIMIZU, D., NOGAMI, Y., TOKUOKA, T., & NOHDA, S., 1970 - Preliminary report on the Permo-Trias of Kashmir. Mem. Fac. Sci., Kyoto Univ., Ser. Geol. Min., 37(2), pp. 163-172.

NEWELL, N.D., & KUMMEL, B., 1941 - Permo-Triassic boundary in Idaho, Montana and Wyoming. Amer. J. Sci., 239, pp. 204-208.

NEWELL, N.D., & KUMMEL, B., 1942 - Lower Eo-Triassic stratigraphy, Western Wyoming and Southeast Idaho. Bull. geol. Soc. Am., 53, pp. 937-996.

RUNNEGAR, B., 1969 - A Lower Triassic ammonoid fauna from southeast Queensland. J. Paleont., 43, pp. 818-828.

SILBERLING, N.J., & TOZER, E.T., 1968 - Biostratigraphic classification of the marine Triassic in North America. Geol. Soc. Amer., spec. Pap. 110.

SKWARKO, S.K., & KUMMEL, B., in press - Some marine Triassic macrofossils of Australia. Bur. Miner. Resour. Aust. Bull. 150.

SWEET, W.C., 1970 - Permian and Triassic conodonts from Guryul Ravine, Vihi District, Kashmir. Univ. Kansas paleont. Contr., Pap. 49, pp. 1-10.

TEICHERT, C., KUMMEL, B., & KAPOOR, H.M., 1970 - Mixed Permian-Triassic fauna, Guryul Ravine, Kashmir. Science, 167, pp. 174-175.

TOZER, E.T., 1965 - Lower Triassic stages and ammonoid zones of Artic Canada. Geol. Surv. Can. Pap. 65-12.

TOZER, E.T., 1967 - A standard for Triassic time. Geol. Surv. Can. Bull. 156.

TOZER, E.T., 1969 - Xenodiscacean ammonoids and their bearing on the discrimination of the Permo-Triassic boundary. Geol. Mag., 106, pp. 348-361.

TOZER, E.T., 1971 - Triassic time and ammonoids: problems and proposals. Can. J. Earth Sci., 8, pp. 989-1031.

TOZER, E.T., 1972 - The earliest marine Triassic rocks: their definition, ammonoid fauna, distribution and relationship to underlying formations. Can. Petrol. Geol., 20(4), pp. 643-650.

VAVILOV, M.N., 1968 - New data on stratigraphy and ammonoids of Indus stage of western part of Verkhoyansk region. Tr. Inst. Geol. Geofiz. Akad. Nauk SSR, Sib. Otd., 48, pp. 5-13.