DISCUSSIONS AND COMMUNICATIONS.

THE UPPER JURASSIC AGE OF THE TENDAGURU DINOSAUR BEDS.

The Tendaguru series of East Africa is interesting to Americans chiefly because its late Jurassic dinosaur horizons, with forms very much like those of our Morrison formation, are interbedded with marine strata replete with bivalves and eight species of ammonites. The work of the Germans up to 1918 was reviewed by the writer in his "Age of the American Morrison and East African Tendaguru Formations," published in the *Bulletin* of the Geological Society of America, vol. 29, 1918, pp. 245-280. A later paper on "The Age of the Morrison Formation," by G. G. Simpson, also reviewed the faunal and stratigraphic evidence of this formation (this Journal, **12**, 1926, pp. 198-216). After the Great War, the English continued the investigation of the Tendaguru series and made further collections of dinosaurs, and Parkinson presented the newer results in his interesting book, "The Dinosaur in East Africa," 1930, following this by a "Note on the Geology of the Country around Tendaguru, Lindi District" (Geol. Surv. Dept. Tanganyika Terr., Short Paper No. 6, 1930). The correlations of the Germans and others were questioned in a critical paper by F. L. Kitchin entitled "On the Age of the Upper and Middle Dinosaur-Deposits at Tendaguru, Tanganyika Territory" (Geol. Mag., vol. 66, 1929, pp. 193-220); on the basis of the bivalves chiefly, he concluded that all of the Tendaguru series above the Nerinea division is of Neocomian or Valanginian age, and that even the Nerinea beds may be of the same general time. The decisive evidence of the ammonites he discounted, saying that "the Jurassic ammonites found in the '*Trigonia smeei*' sandstones are not in their original position, but were derived into those beds, the true age of which must be determined by their latest fossils" (p. 218).

This criticism by Kitchin stimulated Dietrich to restudy most carefully and in great detail all the invertebrate faunas, of which the collections are indeed very large, and the results of this investigation he now gives us in a memoir entitled "Zur Stratigraphie und Palaeontologie der Tendaguruschichten" (Palaeontog., Suppl. VII, 2. Reihe, II, 1933). He was most careful to ascertain whether or not the ammonites show any evidence of having been introduced from older beds, and found no such indications, but admits that they have been drifted from deeper water into these littoral deposits. The marine fauna of the basal Nerinea division, with its many bivalves, had not been carefully studied with a view to age determination, and this Dietrich has now done. The succession of the

various divisions, and their former and present correlations, are given in the following table:

Correlations of the Tendaguru Series of East Africa.
(After Dietrich 1933)

Time	Divisions by Dietrich		Original divisions	Kitchin's correlations
Aptian	Urgonian		Makonda calcareous beds	
Lower Aptian to Hauterivian and upper Valendian	Schwartzi division	Ss. with *T. bornhardti*	*Trigonia schwartzi* ss.	Neocomian
		Ss. with *T. schwartzi*		
	Marked disconformity			Break
Lower Portlandian to Kimmeridgian and Sequanian ?	Smeei division	Upper Dinosaur beds	Upper Dinosaur sandy clays	Neocomian or Valanginian (Valendian)
		Littoral beds with *Cyrena-Mytilus*		
		Ss. with *T. smeei*	*T. smeei* ss.	
		Littoral beds with *Cyrena-Mytilus*		
		Middle Dinosaur beds	Middle Dinosaur sandy clays	
		Littoral beds with *Cyrena-Mytilus*	Nerinea ss.	? Infra-Valanginian
		Ss. with *T. dietrichi*		
			Lower Dinosaur sandy clays	?
			Great break	
			Gneiss	

Parkinson regards the Jurassic succession up to the *Trigonia schwartzi* division as a near-shore series of continuous deposits of a sinking shelf-sea, with the dinosaur divisions as local developments resulting from river delta extensions outward into the sea. The Germans, on the other hand, look upon these alternations of marine littoral and neritic deposits as laid down in an area oscillating between land and sea conditions. The sea bottom and the land were nearly flat, and the streams, flowing easterly through low hills of gneissic rocks, finally meandered through coastal lagoons into the littoral sea. The total thickness of deposits in the Tendaguru series is over 400 feet. There were no coastal cliffs or highlands from which Jurassic boulders with ammonites could have come, and all of the rare conglomeratic material, with the exception of an occasional gneiss pebble, is of intraformational origin. Dinosaur bones were occasionally washed out, but none

of these is rolled and worn, and some of them are overgrown with oysters. The transition from the Lower and Middle Dinosaur beds through the brackish beds to the wholly marine divisions with bivalves, gastropods, rare ammonites, serpulids, echinid spines, corals, crinoids, crustaceans, etc., is gentle, and even the Middle Dinosaur zone passes into marine beds to the north.

In the marine divisions, the bivalves are by far the most common types of animals, and they belong chiefly to the genus *Trigonia*. The shell banks are not constant in their vertical distribution, but shift and change with the changing depth and environment of the bottoms; in places, entire beds are replete with local accumulations of large shells, scattered among which are small bivalves, while ammonites, belemnites, and gastropods are rare. In places, there are local growths of corals.

Dietrich discusses and describes 8 forms of ammonites in 7 genera (3 specifically named), a single nautilid, 2 species of *Belemnopsis*, *Nerinella credneri*, and a *Pseudomelania*; the small patellids, he says, must remain unworked. Of bivalves, there are 90 species or varieties, in the main sand-loving forms; 54 are specifically named, and 17 are new. The new genera are *Indotrigonia*, *Transitrigonia*, *Tendagurium*, and *Epihippopodium*. Most of the bivalves help little to fix the age of the strata, and yet many of the guide fossils of the Schwartzi zone do not occur in the older Jurassic zones, and many of the older ones do not pass up into the Neocomian division. The bivalves do, however, indicate a great time break between the Jurassic and the Cretaceous.

Ammonites are rare in the Jurassic beds and in addition are not well preserved; they are found more often, and in better preservation, in the Neocomian divisions. Locally, small nests of them do occur, along with belemnites, even in the dinosaur zones. Although ammonites are rare and poorly preserved in the Nerinea division, none are of Neocomian or Infravalendian forms. Still more definite, no Portlandian or upper Tithonian forms are present. In the Smeei zone, all are Kimmeridgian perisphinctids, of forms that Spath has named *Katroliceras, Torquatisphinctes*, and *Subdichotomoceras*. Finally, the older zones have nothing indicative of Oxfordian time.

According to Dietrich, while one can argue for an Oxfordian age for the Nerinea division on the basis of bivalves and gastropods, the ammonites nevertheless indicate Kimmeridgian time only. All of the marine Jurassic with its intercalated dinosaur zones up to the Schwartzi division is one unbroken sedimentary and faunal series, and as the Middle Dinosaur division passes north into marine beds, therefore the Nerinea, Middle Dinosaur, and Smeei zones are surely of one continuous series correlating with the Kimmeridgian and lower Portlandian. No upper Portlandian guide fossil has yet been found in the Upper Dinosaur division.

A great paleontological break is indicated between the Schwartzi zone and the Upper Dinosaur beds. The absence of the Purbeckian and the marine Infravalendian indicates a break from upper Portlandian time until at least middle Valendian, since the sea appears to have come back again in upper Valendian or Hauterivian time.

In the Schwartzi zone, nearly all of the fossils are indicative of Cretaceous time, this being true of the ammonites, belemnites, numerous bivalves, some gastropods, and corals. Even the bivalves alone indicate the time to be middle Neocomian.

Dietrich concludes that the bivalves of the Tendaguru series indicate a separation of the series into two parts, namely, an Upper Jurassic Smeei division, and a Neocomian Schwartzi one. At present, however, it is not possible to zone either of these divisions, since the Tendaguru series consists of littoral-neritic sand deposits, and the necessary deep-water calcareous sediments and faunas are absent.

On paleontological grounds, Dietrich agrees with Parkinson that the Nerinea horizon and the two higher Dinosaur divisions are but local phases of Smeei time. As the Upper Dinosaur sandy clays are decidedly thicker than the Middle ones (130 feet against 50), it may be said that the Smeei horizon becomes increasingly brackish upward until the succeeding strata (Upper Dinosaur) are wholly of continental nature. Dietrich's paleontological work therefore confirms Parkinson's postulate of a marked disconformity at the top of the Upper Dinosaur beds.

The Mesozoic faunas of the entire East African Tendaguru series are of an independent marine province, which during the Upper Jurassic had indigenous, Indian, European, and cosmopolitan elements, and in Neocomian time indigenous, European, southern Andean, and cosmopolitan ones. From the widely spread mediterranean Tethys a broad seaway extended through Somaliland and central Arabia. With the Jurassic of India the connections are closer than with the South African Neocomian province. The East African *Trigonia* faunas also shed light on the long known and famous, but at first incompletely understood, bivalve faunas of the Jurassic of Cutch. CHARLES SCHUCHERT.

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