base of a vertically placed wear facet on the inner side of the main cusp. This tooth is obviously derived from a type similar to that behind it by the increase in size of the cingulum.

If we now turn to *Diademodon entomophonus*, Seeley, we find that the hind upper molar agrees in its section with the penultimate molar of *D. browni*; the crown is most unfortunately destroyed. The penultimate molar of *D. entomophonus* shows a further advance; there is still the large main cusp with a smaller posterior cusp, and the cingulum has grown considerably larger, but still supports the original two cusps on its inner side. If we compare this tooth with the corresponding tooth of *D. mastacus* we see a further change in the same direction; there is still the same main cusp with a smaller posterior cusp, but the cingulum is still further exaggerated and now has a small anterior in addition to the two original cusps. This tooth is identical in structure with the much worn antepenultimate molar of *D. browni* and is a typical *Diademodon* molar.

It must be clearly understood that these three species, which occur together, do not stand in any phylogenetic relation to one another, but the series seems to give a clear idea of the origin of the upper molars of *Diademodon*, the 'protocone' being the antero-external cusp and the whole of the inner part of the crown developed by the hypertrophy of the cingulum. If this is the case for the upper molars, it will also follow for the lower teeth, because the main cusp of the upper molar always bites outside the whole lower tooth, and if the lower molar had developed in the reverse way to the upper it would bite into an exaggerated external cingulum. It is remarkable that the view of the origin of the crown of the *Diademodon* molar put forward above agrees exactly in its general lines with the theory of mammalian molar development supported from embryological evidence by M. F. Woodward and from the analogy of the premolar development by many American palæontologists.

II.—GEOLOGICAL NOTES ON THE "LAND OF DEEP CORROSIONS".

By F. KINGDON WARD, B.A., F.R.G.S.

(PLATES V AND VI.)

A YEAR spent amongst the high mountain ranges of the Yunnan-Tibet frontier, where the Salween, Mekong, and Yangtze Rivers have been pinched together till they now flow parallel to one another for 200 miles in a belt of mountainous country averaging about 75 miles in width, enabled me, while prosecuting my botanical exploration, to ascertain a few facts of geological interest which form the subject of the present paper (see Plates V and VI and Figs. 1-4). The Tibetans of Kham, with more eye for the picturesque than one would have given them credit for, have, with amazing intuition, appreciated the subtle distinction between a land of high mountains and a land of deep valleys, and in their classical writings refer to Tibet under the name of *Nam-grog-chi*, which, according to Mr J. H. Edgar, may be translated "the land of deep corrosions"; and this it undoubtedly is.

The Mekong-Yangtze Divide, looking south from the Chun-ma-la, showing scree and buttresses. Photograph taken at about 16,000 ft. elevation.

Before passing on to a description of the country it will be first necessary, for the sake of clearness, to say a few words about the distribution of rainfall and wind over this region, for while the main mountain ranges and valleys are clearly the result of crust movement, other minor topographical features are as clearly the direct result of local peculiarities in the distribution of these meteorological factors.

The prevailing wind is the south-west monsoon, which drenches the many parallel mountain ridges between Assam and China from

FIG. 1. The Yangtze in the arid region looking south, from near Batang, 3,000 miles from its mouth.

FIG. 2. The Salween River in the arid region, below La-kor-ah.

May to October. In about latitude 28° , however, the three main divides with which we are concerned receive such a considerable uplift that the westernmost acts as a partial rain-screen to the next, and so on. Thus there is, first, a high snowy range between the head-waters of the Irrawaddy and the Salween, a second between the Salween and the Mekong, and finally two isolated snow peaks between the Mekong and the Yangtze, all in about the same latitude.

This sudden uplift of the Salween-Irrawaddy divide is sufficient

to check the high rainfall of the Salween valley, and consequently we here pass abruptly from a region of dense forest to a region of semi-desert; the Mekong-Salween divide is even higher, so that while gathering to itself whatever remains of the moisture in the air, and boasting an equally heavy rainfall, the Mekong valley or gorge beyond is, if possible, more desiccated than the Salween valley. But after crossing two high ranges the winds have now little moisture left, so that not only is the Yangtze valley arid but the Mekong-Yangtze divide also (Plate V); thus it stands in marked contrast to the other two rain-drenched ridges.

To return to the valleys. The combined effect of high wall-like mountains and lack of rain causes a local wind to blow in each valley throughout the summer as the heated air rises and cold air sweeps down from the snows immediately above to take its place, and since

FIG. 3. An oasis in the arid region, Mekong River Valley, north of Yangtze.

the gorges get narrower towards the north the partial vacuum is more complete in this direction, and consequently the wind almost invariably blows from south to north up the valleys. It begins about ten o'clock in the morning, reaching its maximum intensity towards evening, and dies away about midnight or rather earlier. Meanwhile the rainfall has been reduced to a few inches a year, and from a distance the valley has the appearance of a desert, except where an alluvial cone, by permitting a little terracing and irrigation, forms an oasis (Fig. 3).

The most abrupt transition from luxuriant vegetation to semi-desert occurs on the Salween (Fig. 2), for the next two valleys are, to a certain extent, deprived of a copious rainfall even south of the snowy ranges, which we have called rain-screens; hence the transition, though obvious, is not so remarkable.

The Mekong River at Tew-kow, looking north, just before the arid region is reached ; the Mekong-Yangtze Divide seen in the distance.

An excellent illustration of the almost physical barrier which seems to be stretched across these valleys at the northern limit of rain is sometimes seen, the clouds, from which rain may be falling at the time, stopping short suddenly, and a ribbon of blue sky following the river northwards, though heavy masses of cloud still rest on the mountain-tops immediately above.

The phenomenon also illustrates the local character of the up-valley winds, for the clouds are entirely unaffected by it, gradually sailing over from the south-west under the influence of the prevailing wind.

In the Mekong valley just south of the arid region brilliant sun haloes are frequent in the summer, usually heralding rain; they are probably caused by clouds which have been blown across from the western range only partially disappearing during their passage over the hot valley, leaving a film through which the sun is seen. The

FIG. 4. Lake occupying a rock-basin at 16,000 feet on the Mekong-Yangtze Divide.

passage of clouds over the arid region on the other hand is often quite invisible, the rain drenching the western divide and later the eastern without affecting the intervening valley.

The effects of this abrupt change of climate in the Salween valley are various. In the first place the appearance of the valley changes from a typical U in cross section to a pronounced V, and at the same time the spurs change their direction from one of more or less parallelism to the main axis, to a direction more or less at right angles to it, thus forming as it were supporting buttresses.

Another change is to be noted in the tributary valleys which, in the arid region, exhibit to a very marked degree the 'reversed' type of structure, whereas in the more rainy regions to the south this structure, though sometimes apparent, is not nearly so conspicuous. [By a 'reversed' valley I mean a valley which begins in the mountains

with a wide opening and gradually contracts as it descends, till finally it slits open the enclosing wall of the main river with a narrow gorge, the last thousand feet or so being over a series of high falls, or, more usually, down a long stairway.]

More interesting is a comparison of the Salween-Mekong divide with the Mekong-Yangtze divide (Plate V), the climatic difference being emphasized by the very different appearance of the peaks in the two cases, those on the Mekong-Salween divide being pyramids, showing clearly the curve of water-erosion, while the Mekong-Yangtze divide is crowned by towers and square-faced buttresses, splintered out by the action of such 'dry' denuding agents as rapid and extreme alterations of temperature, frost, wind, and so on.

The conservative action of the snow blanket on the Mekong-Salween divide must also be taken into consideration, for not only is the snow-line at least 3,000 feet higher on the Mekong-Yangtze divide, but the snow above 14,000 feet on the latter ridge disappears in the spring long before it does from the same altitude on the former, and similarly the Mekong-Yangtze divide is still bare in the autumn long after the Mekong-Salween divide is covered up. Yet these two divides are only 20 miles apart as the crow flies.

Hence, while the Mekong-Salween divide is protected against weathering, there is also available a much greater quantity of water for purposes of transport, so that we do not find here those vast screees which are such a characteristic feature of the Mekong-Yangtze ridge. (Plate V.)

Such differences of climate, of course, cause a marked difference in the vegetation of the two ridges which in turn has its effect on the rocks, partly conservative, partly destructive; but apart from the mere appearance so produced, this is not of great importance to us just now. It will suffice to say that while the rainy Mekong-Salween divide is richly carpeted with plants as high as the snow-line, the scree-clad Mekong-Yangtze divide presents an expanse of semi-desert for the last two thousand feet or so below the snow-line.

As regards the rocks exposed in this region, they may be broadly classed under three heads: (1) limestone, (2) a coarse-grained grey granite, and (3) various metamorphic rocks, though, so far as my experience goes, never with a schistose structure; but whereas similar rocks, limestone, granite, and metamorphic, are common to all three valleys, there is considerable divergence between the two great divides (each of which I crossed by three passes), the Mekong-Salween being capped by igneous rocks and the Mekong-Yangtze by limestone, which readily lends itself to splintering. The region is doubtless rich in minerals, and I have on one occasion climbed a mountain which seemed to consist almost entirely of some metalliferous ore.

We will now pass on to consider an important point in connexion with the Mekong-Yangtze divide, namely, the evidence for previous glaciation.

I have mentioned two snow mountains on this divide, one of which I saw very clearly, though I did not visit it; but the glaciers are

certainly retreating, their bottle-nosed snouts being already some distance from the terminal moraines. Other evidence is derived from the 'hanging' valleys which descend immediately from the watershed and their peculiar 'tread and riser' structure, the valley floor ascending in a series of long abrupt steps to higher levels, each platform being the receptacle for a small lake occupying a rock-basin, one of which is shown in the photograph (Fig. 4, p. 151). Sometimes as many as five such lakes may occur in one valley, but usually there are fewer. Finally, we have the huge accumulations of angular rock fragments at the heads of the cirques, some of which at least are probably parts of old moraines. Of perched blocks and stræ, however, I saw no sign, though I do not attach much importance to that, for the climate is now all against their preservation.

Now it is evident that if the Mekong-Yangtze divide received as heavy a rainfall as does the Mekong-Salween divide there would be glaciers on the former where none now exist, so that the disappearance of the glaciers may be ascribed to a diminution of the rainfall. Why, then, has the rainfall become less? Evidently because it has been gradually cut off by the ranges to the west thrusting themselves up higher and higher till at last they form effective rain-screens. Nor is this all. Aneroid readings taken at different points in the beds of all three rivers show that the Yangtze flows at an average level of about a thousand feet above the Mekong, and the latter about the same height above the Salween, indicating a general western tilt of the country as it were, which within recent geological times has probably been in a condition of considerable instability; nor, indeed, are earthquakes rare, slight tremors being, I believe, frequent, which may help to account for the number of landslips, while hot springs issue from the base of every range. Such a tilt might easily cause a cracking of the crust, suggesting that these rivers really break through the rim of the Tibetan plateau along lines of weakness (fissures) or faults; but without believing for a moment that they have themselves carved out the deep gutters where they now flow, there is evidence, particularly in the Mekong gorges, for a very considerable amount of spade-work—for instance, pot-holes and ancient river cliffs now many feet above the highest flood-mark.

The crumpling and tilting of the rocks shows how the country has been pounded this way and that, but the general appearance points to a lateral pressure acting from the west (such as might be occasioned by a slight sliding motion of the main Himalayan axis eastwards), squeezing the belt of country up against an unyielding barrier in western China (supplied by the main east and west axis of uplift, separating the two great river systems of China), thus gradually raising the Mekong-Salween divide to its present considerable elevation, and so cutting off the rain supply of the older easternmost ridge—that remarkable freak of nature, the Mekong-Yangtze divide.

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