



第二卷·冰川地质
Volume II Glacial Geology

李四光全集

The Complete Works of Li Siguang

湖北人民出版社

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目 录

Note on Traces of Recent Ice-action in N. China	1
Quaternary Glaciation in the Yangtze Valley	16
Data Relating to the Study of the Problem of Glaciation in the Lower Yangtze Valley	80
Confirmatory Evidence of Pleistocene Glaciation from the Huangshan, Southern Anhui	130
Quaternary Glaciation in the Lushan Area, Central China	144
Vestiges of Corrie-glaciation on the Kweichow Plateau	260
华北挽近冰川作用的遗迹	294
扬子江流域之第四纪冰期	304
关于研究长江下游冰川问题材料	349
安徽黄山之第四纪冰川现象	384
冰期之庐山	395
鄂西川东湘西桂北第四纪冰川现象述要	487
中国冰期之探讨	500
贵州高原冰川之残迹	514
三门峡第四纪地质会议论文集序言	534

2 目 录

在中国第四纪冰川遗迹研究中心联络组座谈会上的 发言	536
在中国第四纪冰川遗迹研究中心联络组座谈会闭幕 式上的发言	544
北京西山区第四纪冰川遗迹和中国冰期问题	551
就华北平原打井谈冰期问题	559
华北平原西北边缘地区的冰碛和冰水沉积	569
有关第四纪冰川地质工作的谈话	594
有关第四纪冰川工作远景规划问题的一封信	629
关于螺吉山第四纪冰川工作的一封信	631

Note on Traces of Recent Ice-action in N. China^①

The question whether N. China was under the grip of Polar severity towards the close of the Tertiary or the beginning of the Pleistocene time, and whether there was sufficient precipitation to allow the existence of large glaciers even if the temperature had become for a time arctic, has, on account of its important bearing on the problem of the cause of glaciation, aroused from time to time forcible but conflicting arguments. As cumulative evidence tends to show the wide prevalence of desert conditions all over N. China throughout recent geological times, geologists seem to have generally agreed, and naturally so, to provide a negative answer to the second part of the question. But as to the first part, it remains so far completely shrouded in doubt. In matter of this kind nobody would expect to wrest out truth by mere theoretical contention. Any relevant fact, therefore, deserves to be placed on record.

① 原载英国《地质杂志》第59卷，第1期，第14—21页，1922年1月。——编者注

Two cases are now available that seem to afford a strong ground to prevent us from admitting the hitherto accepted view.

(1) In journeying across the coal-basin of Sha-ho-hsien, southern Chi-li, I sighted from a distance a singular hill-range of moderate height, called the Sha-yuan-ling. The range possesses a round contour, and trends E. S. E. — W. N. W. The E. S. E. end of the range is separated by a deep valley from another hill-range running N. N. E. ; and the W. N. W. part of the Sha-yuan-ling gradually flattens out towards the loess plain so that the whole hill constitutes a topographical unit.

As I approached the Sha-yuan-ling from the south-west strange boulders began to appear. Being pre-occupied by the idea that desert conditions prevailed throughout recent geological times in N. China, I sought all conceivable ways other than glaciation to account for the presence of these erratics, but in vain, for the topographical features of this isolated hill do not admit the assumption that they have rolled down from the hills to the southeast, still less likely were they brought down by a pre-existing stream. Before, however, I reached the northern foot of the Sha-yuan-ling a cliff on the hillside suddenly came in sight (Fig. 1). Large and small blocks or boulders are seen in this natural profile. They are scattered at random in a clayey or sandy material, and are generally polished on one or two, but rarely more than two, surfaces. The edges of the blocks are in the majority of cases fairly sharp except those between the polished surfaces, which

are as a rule rounded. Although the finer material that forms a part of the deposit bears here and there suggestions of stratification, they disappear in a very short distance. The rock is as a whole unstratified and unconsolidated. Were it found in N. W. Europe or N. America, I doubt if any one would hesitate for a moment to call it Drift or Till. It was this general appearance of the rock that inspired the conviction that if a patient search be continued striated pebbles or blocks could no doubt be found among the fragments.

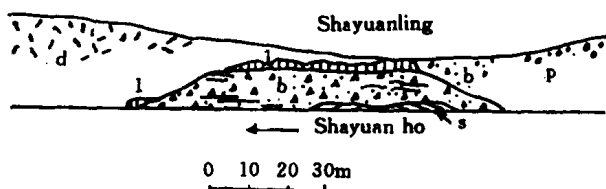


Fig. 1 The Sha-yuan-ling from the S. W. —l, loess; p, pebble-bed; b, boulder-bed; s, sandstone; d, dolerite.

A systematic search was at once started. Keeping always a particular object in view, I could perceive now and then suggestions of obliterated striation on the polished surfaces. After toiling for more than two hours, a large slab half-buried (Fig. 2) was found; on its flat surface at least three sets of striæ could be clearly observed. Following this find two more striated fragments of similar character fell under my notice (Pl. I, Fig. 1). Judging from the extraordinarily regular

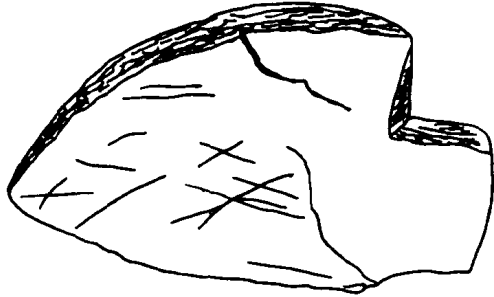


Fig. 2 A striated slab found in the Sha-ho-hsien Conlfield, Chi-li, N. China. Max. length and width, 125×70 cm.

parallel grooves and ridges on their flat surfaces, the suspicion is not absent that they might be merely slickensides. The origin of these fragments, however, does not seem to affect in a serious way the evidential value of the first slab; for evidence is brought forward by Coaz, Heim, Pasquier, and others that an avalanche sometimes slides down hillslopes like a landslip, and heaps up masses of fragmentary rock or boulders in the valley^①. Moreover, it is well within all possibilities that some of the fragmentary rocks had already undergone a process of rubbing before they were transported by the ice.

① Coaz, *Die Lawinen in den Schweizer Alpen*, Berne, 1881. Heim, *Die Gletscherlawine an der Altels am 11 September, 1895*, Zurich, 1895 (*N. N. G. Z.*, 1896), pp. 11–17. Pasquier, *L'Avalanche de l'Altels le 11 September, 1895*, Neuenburg, 1896.

The boulders largely consist of sandstones of many kinds. Some of them are members of the coal-bearing series, others are foreign and unknown in origin. A green tuff-like sandstone and a hard quartz-sandstone frequently occur in huge blocks with one side well polished. The former is entirely unknown in the surrounding country; the latter caps the hills to the south-east of the Sha-yuan-ling, and extends discontinuously for more than 60 miles southward. Cherts and wind-faceted pebbles are now and then found among the more comminuted material. Well-rounded quartzitic pebbles of the size of Easter eggs rarely occur, and appear to be limited to the upper part of the deposit. The Sinian Limestone which forms the high range of the Tai-hang to the west is singularly absent; while the presence of the hard quartz-sand-stone, dolerite, etc, indicates that a part of the boulders are of local origin or arrived from the south.

The deposit rests upon a denuded anticline, pitching slightly towards the north-east. The exposed part of the anticline consists of a buff sandstone which lies well above the zone of *Pterophyllum carbonarium* Schenk^①. Above the deposit there is a mantle of loess. As far as can be judged from the suggestions of stratification, both the loess and the rock immediately underlying it are slightly arched in a conformable manner. No signs of erosion were detected in the contact plane of the two, though sharply defined. Thus it appears that there

① China, vol. iv, p. 214, pl. xlv, figs. 4, 5.

has never been any violent tectonic disturbance, but possibly a pre-loess landslip or avalanche that might have given rise to the striation on some of the boulders. But landslip alone cannot explain all the observed facts.

A hummocky hill forms the eastern portion of the Sha-yuan-ling. The upper part of it is composed of dolerite, probably in the form of a laccolithic intrusion. A few but conspicuous strange boulders lie here and there on the hill-top like ruins of great antiquity. Polished and scratched or grooved surfaces are seen everywhere. These differ in many respects from the curious grooves that have been occasionally noticed on the igneous intrusions in the South Staffordshire coalfield and elsewhere. The latter, for instance, are usually irregular and slightly wavy or curved, while the lines or grooves on the loose fragments of the dolerite of the Sha-yuan-ling are not only of frequent occurrence on the whole surface of the hill, but are quite straight and sharply defined. Clearly, then, they are in no way comparable.

It should, however, be mentioned that some of the fragments possess peculiar smooth and striated surfaces. These can be easily distinguished in the field from the polished and scratched surfaces by the fact that they are either slightly warped, often with a glossy brown incrustation, or exhibit rudely parallel wrinkles with a projecting rim attached to the edges or the corners. Fragments having this kind of surface look as if they had been partially moulded in a more or less plastic condition, or, what is more likely, had been carved out

by a neighbouring fragment shifted under intense pressure. Such pressure, it is not difficult to imagine, might have been set up by differential expansion of the rock-mass due to a sudden rise of temperature, or might well be exerted by a great mass of ice that under special circumstances could have concentrated its pressure on a number of crumbled rock-fragments. When we reflect over the profound contortion of well-laminated rocks produced by ice-action, this apparently wild assumption seems plausibly to claim some respect.

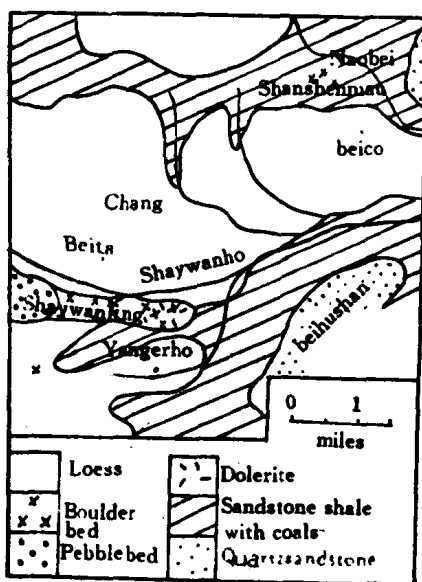


Fig. 3 Geological map of the Sha-yuan-ling district.

Judging from the occurrence of huge blocks of the hard

quartz sandstone 1.5 miles south-west of the Sha-yuan-ling and from the north-easterly axial trend of the anticline already mentioned, it seemed probable that the hypothetical glacier might have taken advantage of the denuded anticline and directed its course towards the north-east. If this be the case, we should expect to find traces of glaciation in the hills further north-east. This is borne out by fact.

About 3.5 miles north-east of Sha-yuan-ling a roundish knoll rises above the loess plain with a small temple, the Shan-shien-miau, standing on its top as a conspicuous landmark. A small valley runs along the northern foot of the hill in a south-easterly direction. At Nau-pei-kou, a few hundred yards north-east of the Sha-shien-miau, and about 1 mile north of the Pei-tso village, the trend of the valley is slightly deviated by a hill-spur projecting from the south. Here, bedded green and buff sandstones, belonging to the uppermost part of the coal-bearing series, are well exposed. In the bottom of the valley parallel grooves are seen on the surface of an extremely hard sandstone in situ. The surface appears to be on the whole horizontal but locally undulatory, showing decisively that it has been planed or abraded by some powerful agent. All of the grooves run north-east, except for a minor set which cuts the former at a very small angle.

The sandstones dip regularly south-east. No sign whatsoever can be detected pointing to the existence of a thrust or a fault. One of the abraded beds in the bottom of the valley exhibits a partially striated, concave surface with its

striated part inclined towards the north-east; while the unstriated part, namely, the north-eastern part, tends to curve upward towards its north-eastern edge. Such a state of things could not possibly have been brought about by a dislocation of the bedded rocks, nor could it be attributed to the hypothetical expansion and consequent slip of an overlying stratum.

It may be reasonably questioned that if a glacier did actually occupy the valley during a recent geological time, how could it have left traces of its movement across the valley instead of along it, since the latter would be a far more natural course? To answer this question we need to know the nature of the valley and the topography of the surrounding country. The valley, or more properly the ravine, is only of very small size, being 20 to 30 feet wide at the bottom and not much deeper than 200 feet from the bottom to the top of the hill on the south. Therefore an ice-sheet of moderate thickness could have indiscriminately buried the whole area, and made its movement quite independent of the local irregularities of the floor. The occurrence of strange blocks and fragments of rocks on the top of the hill of the Shan-shien-miau, which stands much higher than the hill just referred to, and the heavy abrasion that the bedded rocks of Nau-pei-kou must have gone through are facts which combine to demonstrate the considerable thickness of the ice.

The boulder-bed of the Sha-yuan-ling, as already mentioned, is quite loose and in a way conformable with the

overlying loess. A priori it is a geologically recent deposit. If the quartzite pebbles occurring in the upper part of the boulder-bed be genetically connected with the so-called pebble-bed of northern Honan, then the age-problem can be at once solved; for we know definitely that the pebble-bed is everywhere else immediately overlain by the loess. Meanwhile, let us turn to the fossil evidence. Cases are known that the so-called *Pterophyllum carbonarium* Schenk associates with forms closely related to *Nilssonina*. This would mean that the upper part of the coal-bearing series either belongs to the Permo-Mesozoic or even entirely to post-Palaeozoic. In any case the possibility of the boulder-bed belonging to the Permo-Carboniferous can be absolutely excluded. It might be, however, urged that the icemarked rock-fragments could have been originally produced in some period earlier than the late Tertiary or early Pleistocene, and became re-arranged before the dawn of loess time. But if this be the case, how could the gigantic blocks of rocks, entirely unknown in the neighbourhood, be brought to their present resting place? How can the unstratified state of the deposit be explained if the material was wholly transported by water? Why are some of the fine striæ and most of the sharp edges of the boulders or fragments remarkably well preserved? It would be extremely difficult, if not impossible, to find a satisfactory explanation save on the basis of recent glaciation.

(2) During a reconnaissance in the Tatung Basin, Northern Shan-si, I was struck above the village of Kou-tsuen (about

latitude $40^{\circ}5'$ N. , longitude $113^{\circ}15'$ E.) by a U-shaped valley which extends a little less than 10 miles in a west-east direction, and shows a wonderfully uniform width throughout its entire length. In the valley there occur strange boulders consisting of gneiss, schists, basalt, and many other kinds of igneous rocks. They are not derived from the hills on both sides of the valley, nor from the watershed that separates this valley from the broad expanse of lowland which forms the western part of the basin; for all these hills are composed of piled-up horizontal or nearly horizontal strata of Jurassic sandstones, which on the top of the watershed are covered by the loess and near the entrance of the valley are replaced by the Palaeozoic coal-bearing series and the Sinian Limestone. Thus it is beyond doubt that the boulders are not of local origin. As there appears no sign that the present valley had once extended across the watershed, the boulders could not have been transported by a pre-existing river whose source might have extended far back into the mountains on the west of the Tatung Basin.

The side of the valley is sometimes so steep, particularly in its lower part, that it almost merges into a cliff, assuming the shape of a snubbed hill-spur. Near the base of one of such cliffs a block of dislodged sandstone was found, which exhibits coarse parallel furrows on one of its surfaces. The bottom of the valley is filled up by stratified but hardly consolidated rock-debris, attaining a thick-ness of more than 20 feet in many places where the river erosion has gone so far as to

permit measurement. Above this deposit there is as a rule a mantle of loess. On the bottom of the valley several sub-angular, half-polished and scratched boulders, or pebbles, were found at different localities (Pl. I, Figs. 3, 4). They appear to be closely associated with the detritus deposit. As far as I am able to judge, no distinction can be made between these and any of the typical striated boulders found in the Boulder-clay. It is inconceivable that they are of different origin.

If the facts brought forward here amount to positive evidence of recent glaciation, as they appear to the writer, we may proceed to consider what data are available to show that these are not merely local phenomena. In the case of southern Chi-li the mean altitude of the glaciated area cannot be much more than 300 feet above the vast alluvial plain of N. E. China, and no enormously high mountains could have existed in its neighbourhood which might have let down boulders from their ice-caps in late Tertiary time, and have since been planed away or subsided. Moreover, the quartzite pebbles or the "Egg-stones" already referred to, are known to occur in multitudes on many a hill-top east of the Tai-hang range; and they are everywhere immediately overlain by the Hwangtu or the loess. Seeing that these quartz pebbles associate with striated boulders in the Sha-yuan-ling, it does not seem improbable that they maintain elsewhere a similar relation with the glacial deposit. As regards the possibility of local glaciation due to great elevation of land, the argument used to dispose of the