

# 内蒙古大青山水磨沟发现末次冰期冰川堆积物

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**摘要** 内蒙古大青山水磨沟发现晚第四纪冰川堆积物。冰碛物主要为红褐色泥砾混杂堆积, 不发育层理, 杂基支撑, 泥砂质成分约占60%, 砾石占40%。砾石磨圆好, 表面发育铁质膜及不同方向擦痕。大于50%的砾石发生了蠕变剪切变形, 形成各种张扭剪切破裂。分析认为, 松散堆积物中大量砾石具有这种变形破裂, 很可能是冰川蠕变变形的结果。上覆沉积物的<sup>14</sup>C测年结果限定这套冰碛物形成于1.3万年之前。因此, 这应该是华北北部41°N附近的中低山区发现的可靠的末次冰期冰川遗迹。

**关键词** 第四纪, 冰碛物, 末次冰期, 大青山, 水磨沟, 内蒙古

中国现代冰川主要分布在105°E以西的青藏高原、祁连山、天山、横断山、昆仑山、念青唐古拉山等地, 而东部获得广泛认可的第四纪冰川只分布在太白山、长白山、台湾的雪山和玉山<sup>[1-3]</sup>。广阔的东部低山区是否存在过第四纪冰川, 一直存在争议<sup>[1,4]</sup>。20世纪初, 李四光提出中国东部许多中低山地, 如庐山、黄山、北京西山、太行山等都发育过第四纪冰川<sup>[5,6]</sup>。后来被明确地否认了<sup>[1]</sup>, 但最近几年又逐渐地出现了一些关于东部第四纪冰川的报道<sup>[7-10]</sup>。中国东部是否存在第四纪冰川, 对认识东亚大陆气候特征和我国第四纪环境变化具有重要意义。

大青山位于华北北部阴山中段, 北坡平缓, 剥蚀残余的低山丘陵和盆地交错分布, 逐渐与内蒙古高原相连; 南坡陡峭, 与河套平原高差可达100~700 m。大青山武川以南水磨沟一带, 最高峰海拔2200 m。遥感影像显

示, 沿水磨沟发育南、北两个冰蚀洼地, 其中北洼地呈菱形, 东西长10 km, 南北宽6 km(图1(a)和(b)); 南洼地呈北宽南窄收口的漏斗状, 东西最宽处约7 km, 南北宽5 km(图1(a))。残留冰碛物分布在北洼地, 沿一条现代间歇性河流西岸的一处河湾处堆积。冰碛物堆积体南北长约500 m, 东西宽约400 m, 覆盖于古元古代大理岩之上(图1(c))。

残留冰碛物主要为砖红-红褐色的泥砾混杂堆积物, 不发育层理, 泥砂质成分约60%, 砾石约40%, 杂基支撑。冰碛物中粗、中、细砾在砾石中的比重基本相同, 见少量巨砾, 砾径最大超过1 m。砾石主要为花岗岩、片麻岩、辉绿岩、斜长角闪岩等, 没有发现近源大理岩砾石。砾石分选差, 磨圆好, 以次圆状、浑圆状为主(图2)。

冰碛物中砾石具以下特征(图2): (1) 表面普遍发育光滑的褐红色铁质膜及不同方向的擦痕; (2) 大部分砾石

发生了不同程度张扭性剪切变形, 露头上直径大于10 cm的砾石几乎都被剪切变形; (3) 砾石变形主要为张性剪切破裂, 多表现为“裂而不破”。露头上所见最大的一块变形砾石中发育一组X形剪切破裂, 破裂面发育最密集处位于砾石中部, 砾石仍未破裂开(图2(g))。

什么样的构造作用导致松散堆积物中的砾石大部分发生强烈的剪切变形? 一般地, 坚硬固结砾岩或含砾岩石被断层或节理切过时, 只有那些被断层或节理直接切过的砾石中才能见到剪切变形, 且往往是被直接切断断开。作者认为, 本文所报道的松散沉积物中砾石大量变形的情况, 很可能是裹挟在冰川中的砾石, 在冰川蠕变过程中, 使冰碛砾石普遍发生张扭性剪切变形, 这显示了蠕变状态下的剪切变形特征<sup>[11]</sup>。因此, 大青山水磨沟出露的这些松散堆积物显示其具有明显冰川成因特征。

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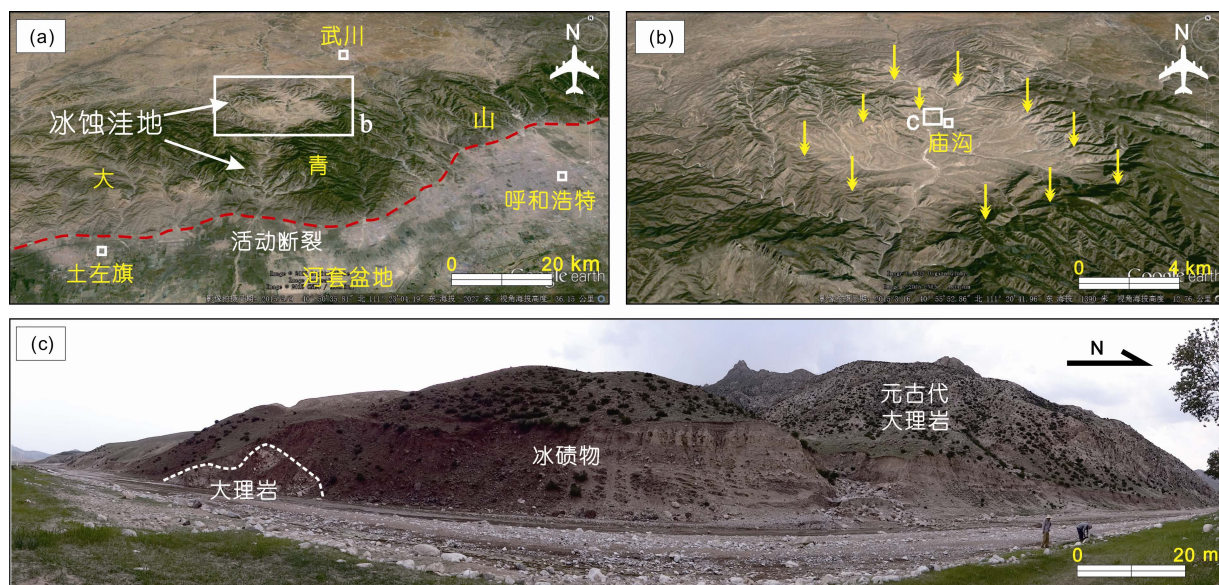


图 1 内蒙古大青山水磨沟冰川地貌遥感影像特征. 遥感影像来自 Google earth. (a) 水磨沟地区遥感影像及冰川遗迹位置; (b) 北洼地; (c) 水磨沟冰川沉积物剖面

**Figure 1** Remote sensing images showing features of glacial landforms in the Shuimogou area, Daqing Shan Mountain, Inner Mongolia (images obtained from Google earth). (a) Remote sensing image and location of glaciers in the Shuimogou area; (b) northern depression; (c) field photograph showing the Shuimogou glacial sediments

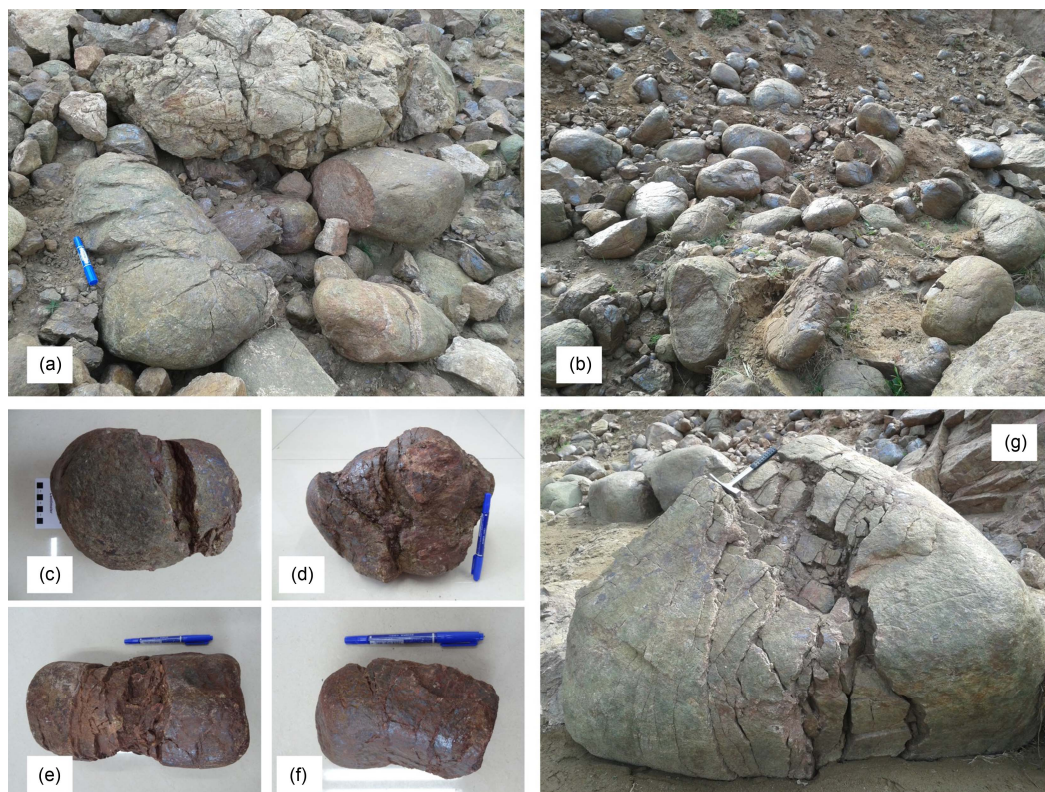


图 2 内蒙古大青山水磨沟冰碛物特征. (a), (b) 冰碛物野外露头, 大量砾石发生剪切破裂; (c)~(f) 张扭性破裂的砾石, 表面发育褐红色铁质膜及不同方向的擦痕; (g) 露头上见到的最大变形砾石, 砾石中部发育 X 形剪切破裂

**Figure 2** Features of glacial till in the Shuimogou region, Daqing Shan Mountain, Inner Mongolia. (a), (b) outcrops of glacial till, pebbles were strongly extensional twisted shear deformed; (c)~(f) tensile-torsional sheared pebbles, surface are coated with brownish red iron jacket and glacial striae with random directions; (g) the biggest deformed boulder founded in the outcrop, "X" shearing fractures developed in the middle part

冰碛物之上覆盖更新的近源山麓残坡积物、冲洪积物。冲洪积物底部为厚的冲洪积砾石层,砾石主要为近源的大理岩,砾径0.3~1 m;中部为含砾中-薄层粉砂、黏土夹砾石层,砾径平均3~5 cm;上部为较粗的冲洪积大理岩砾石层,砾径平均2~3 cm;顶部为

厚约0.5 m的腐殖土层。测年样品(DQS04-1)采自中部厚度约5 cm的深灰-灰黑色黏土夹层,在Beta实验室进行 $^{14}\text{C}$ -AMS(加速器质谱)测年。参照Talma等人<sup>[12]</sup>的方法,采用INTCAL09数据库对测试结果进行校正。获得 $2\sigma$ 校正年龄为13565~13440 cal a BP,表明冰

碛物沉积时间早于1.35万年。

因此,内蒙大青山水磨沟发现的残留冰碛物属于末次冰期冰川作用堆积产物。它的发现表明,中国东部41°N附近的中低山区可能存在第四纪冰川,这对认识东亚大陆气候特征和我国第四纪环境变化具有重要意义。

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# Discovery of glacial deposits in last glaciation of the Shuimogou area, Daqing Shan Mountain, Inner Mongolia

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The current Quaternary glaciers in China only distribute on the high mountains surrounding the Tibetan Plateau in the west of 105°E. In the east of 105°E, glaciers only exist in Taibai Mountain, Changbai Mountain, and Snow Mountain and Yushan Mountain in Taiwan. Whether the Quaternary glaciation reached the lower elevation foothills and uplands in the east of 105°E is usually causing intense disputations among the researchers. This discovery of the glacier deposits in the Shuimogou areas of the Daqing Shan Mountain has provided confident evidence that the glaciers did cover the lower elevation hill ranges during the late Quaternary glaciation.

Daqing Shan Mountain is located in the middle part of the Yinshan Mountain, Inner Mongolia. The highest peak is 2200 m above sea-level. Remote sensing images indicate that there are two glacier eroded depressions within the Shuimogou valley. In the northern depression, the glacier deposits distribute around 500 m in NS direction and 400 m in EW direction and overlap the Proterozoic marble. The glacial deposits are mainly brownish red tillites composed with 60% sandy mud and 40% pebbles. There is no clear bedding within these morainic sediments. Pebbles have poor sorting, well rounding, and are cemented by mud and muddy sand. The major components of the pebbles are granite, gneiss, diabase, plagioclase-amphibolite. No underlying Proterozoic marble pebble has been found in the tillites, so the tillite components should experience long-distance transportation from their source regions. The pebbles have following characters: (1) the smooth pebble surface is coated with brownish red iron jacket; (2) the glacial striae on the pebble surface show random directions; (3) on all of outcrops, almost all pebbles with the size larger than 10 cm show the fractures of the strong extensional twisted shear deformation. The presence of intensive twisted pebbles distributing in the loose sediments indicates that the pebbles must be deformed during their transportation—glacier movement. During the outcrop creep of the glacier, the shearing force from the squirming of the ice tore the pebbles and created the pebble deformation.

The tillites are covered by the landslides from nearby hill slopes and the flood deposits. A 0.5 cm thick of dark gray mud bed is interlayering within the middle of the flood deposits. The clays in the mud have been sampled for <sup>14</sup>C-AMS age dating (DQS04-1). The age dating was performed in Beta laboratory. The <sup>14</sup>C age was corrected by 2 $\sigma$  and the results are 13565 to 13440 cal a BP. This result indicates that the morainic debris deposited before 13.5 ka. These Daqing Shan tillites should form from the latest Quaternary glaciation. The identification of these glacier deposits proved the existence of Quaternary glacier in the foothill and highland area, east of the 105°E longitude around the 41°N latitude region. This discovery has significant importance for the study of geological history in this region and shines a light on the research of the climate evolution in East Asia and the Quaternary environment change in China.

**Quaternary, glacial till, Last Maximum Glaciation, Daqing Shan Mountain, Shuimogou, Inner Mongolia**

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