

Table S1. Statistics of ages for remains of permafrost, periglacial and glacial environments in China during the Quaternary

| Epoch | Stages of permafrost evolution | Locality | Latitude (N) | Longitude (E) | Elevation (m asl) | Types & geomorphological positions of past permafrost | Dating method* | Age (BP) | References |
|-------------------------------------|------------------------------------|--|--------------|---------------|-------------------|---|------------------------------------|---|---|
| Early Pleistocene (2.58-0.78 Ma BP) | Early cold period | N Lake of Hangai Mts. in Mogolia, NE China & Altai & Tianshan Mts. | 47°~50° | | | Lacustrine sediments invaded epigenetic permafrost | Stratigraphic | | Gravis et al., 1974 |
| | | Zanda Basin, Ngari, Tibet | 31°49' | 79°38'~79°40' | 4287~4538 | Involutions, fluvio-alluvial & periglacial deposits, cold climate flora, fauna & microfossils | ESR | 2.68-2.45, 2.45-2.11, 2.11-1.49 and 1.49-1.36 Ma | Zhu et al., 2006 |
| | Xixiabangma Glaciation (MIS 36~20) | Gl morainic platform N of Xixiabangma Peak | 28°21'18" | 85°46'44" | 4680~8027 | Gl morainic platform (6,200 m asl) | Geomorphology | 1.17~0.8 Ma | Zheng & Shi, 1976; Zheng et al., 2002; Li et al., 1991a |
| | | Yalu Zangpo | | | | Glacial till | ¹⁰ Be- ²⁶ Al | 1.0 Ma | Yi et al., 2018 |
| | | 3rd terrace, Hanjiang tributary, Zhongxiang, | 31°10' | 112°34' | 650 | Involutions, ice wedge casts, gravel wedges | TL | 1.106 Ma, gravely sands with <i>Stegodon orientalis</i> | Chen et al., 1990 |

| | | | | | | | | | |
|---------------------------------------|---|--|---------------|----------------|----------------|---|--------------------|-------------------------------|---|
| | | Jiangnan Plain | | | | | | | |
| | | Baitushan Group | 46°40' | 121°50' | 450 | Involutions | Stratigr | | Sun, 1981; Sun et al., 2007 |
| | | Zhoukoudian, Beijing | 39.6888 | 115.92516 | 145 | Ice-wedge casts, cold climate micro-fossils, flora and fauna | Paleo- magnetic | 900~730 ka | Cao et al., 1989 |
| Middle Pleistocene (780-130 ka BP) | Wangkun- Kunlun - Antepenultimate & Naynayxungla Glaciation (MIS 18/20~16: 780~620 ka) (Glaciated extent >500,000 km ²) | Kunlun Mountain Pass | 35°40' | 94°50' | 4,650 | Glacial till | ESR/TL | 710±228 & 543.47±109.69 ka | Cui et al., 1998 |
| | | Gulia Ice Cap in the West Kunlun Mountains | 38° | 81° | 6800 | Basal ice core | 36Cl | 760.0±60.0 **; >500 ka | Thompson et al., 1997, 2006 |
| | | Past ice cap zone at Daochang, W Sichuan | 29.3821° | 100.0961° | 3800 | Red glacial till of Daocheng Glaciation | ESR | 571.2 ka | Zhou et al., 2005 |
| | | Kuzhaori, Daocheng, W Sichuan | 29.3821° | 100.0961° | 3800 | Oldest glacial boulder | CRN | MIS 16 | Wang et al., 2006 |
| | | Yulong Snow Mountains | 27°10'~27°40' | 100°9'~100°20' | 3600 | Yulong Glacial till | ESR | 600-700 ka BP | Zhao et al., 1999; Guo et al., 2001 |
| | | Ningzhong in W NianqenTanggu la | 30°40' | 90°-97° | 5100 ~ 5700 | Carbonate nodules in glacial till | ESR | 600-700 ka BP | Zhao et al., 2002; Wu et al., 2003 |
| | | N of Amur | 56-64 | | | Ice wedge cast | | | Fotiev et al., |

| | | | | | | | | | |
|--|--|---|---|--|---|--|----------|------------------------------------|-------------------------------------|
| | | (Lena-Vyliuyi lowlands (64°N) | | | | continued to 56°N | | | 1974 |
| | | Tianchi Forestfarm in middle Da Xing'anling Mts. | 48° | 119°28'-121°23' | 1332 | Gravel wedge & strata | Stratigr | Mid-Pleistocene | Zhou et al., 2000; Sun et al., 2007 |
| | | E of Gangcha and Quanji Village at N bank of Qinghai Lake | E of Gangcha (37°15'43.7"); W of Quanji (37°14'22.2") | E of Gangcha (100°00'28.4"); W of Quanji (99°50'13.0") | E of Gangcha 3,238; W of Quanji 3,235 m | Sand wedges | ESR | Wedge bottom at 774±70 & 773±70 ka | Qi et al., 2014 |
| | | Kunlun Mt Pass | 35°40' | 94°50' | 4,650 | Glacial till | ESR | 710.0±109.7 ka | Cui et al., 1998 |
| | | Between Damxung & Yangbajing on SE slope of E Nianqen Tanggulha | 30°10' | 91°30' | 4,580 | Glacial moraines | ESR | 678.0±30.7 ka | Shi, 2006 |
| | | Nia Valley on N Slope of Damxung | 30°25' | 90°50' | 4,600 | Carbonate nodules in glaciofluvial sediments | ESR | 678.0±59.3 ka | Wu et al., 2003 |
| | | Yunshanping, | 29.3821 | 100.0961 | 3800 | Glacial till | ESR | 592. 6±118. 5 ka | Zheng, 2000 |

| | | | | | | | | | |
|--|--|---|---------------------|-----------------------|-----------|--|----------------|-----------------------------------|--------------------------------------|
| | | Yulong Snow Mts. | | | | | | | |
| Great Interglacial warm & wet period: Continuous high $\delta^{18}O$ (ca. 620~480 ka: MIS 15~13) | | Nia Valley Outlet on N Slope of Damxung | 30°25' | 90°50' | 4,650 | Carbonate nodules in glaciofluvial sediments | ESR | 593.0±60.0 ka | Zhao et al., 2002 |
| | | Glacial remains in Shaluli, Daocheng, W Sichuan | 29.3821 | 100.0961 | 3800 | Red paleosol from weathered glacial till | ESR/CRN | 571.2 (MIS14) 700-400 ka | Zhou et al., 2003 |
| | | Luochuan Loess | 35°45' | 109°25' | 1135-1160 | Three red paleosol layers | Paleo-magnetic | MIS15 Warmest (+5°C, +100-200 mm) | An & Wei, 1980 |
| | | 3rd terrace of Heilongjiang at Syation 18, Huma | 52°23'42"~52°25'12" | 125°19'54"~125°29'26" | 300-744 | Yellow & brownish paleosol | Stratigr | | Chen et al., 1990; Tong et al., 2014 |
| | | Zhoujiayoufang, Jilin; Harbin; Nihewan, Yangyuan, Hebei; Three Gorges | | | | Involutionsand Stephanorhinus kirchbergensis fossils | Stratigr | | Chen et al., 1990; Tong et al., 2014 |
| | | Zoigé Borehole RM | 33°54.27' | 102°32.70' | 3396 | Dominance of needle-leaved pollensw | 14C | MIS 13 as major warm period | Liu et al., 1994 |

| | | | | | | | | |
|---|---|----------------|--------------|----------------|---|-----|--------------------|---|
| Zhonglianggan n Glaciation (MIS 12, c. 480- 420 ka) | Zhonglianggan, Bailanghe, Hei'he, Qilian Mts. | 39°05' | 98°30' | 2,640- 2996 | Zhonglianggan glacial till | ESR | 462.9 ka | Zhou et al., 2001, 2002a |
| | Headwater area of Urumqi River | 43°01' | 86°29' | 3,400- 3500 | Gaowangfeng glacial till | ESR | 471.1; 459.7±46 ka | Zhou et al., 2001a, 2002b; Zhao et al., 2006 |
| | Qingshantou, S slope, Tumor Peak, Tianshan Mts. | 42.1 | 80.3 | 7,435 | Glacial platform | ESR | 440.6±41.7 ka | Zhao et al., 2009a, 2009b |
| | East of Tumor | 42.1 | 80.3 | 7,435 | Highest morainic platform | ESR | 418.9 ka | Zhao et al., 2009a, 2009b |
| | Ganhaizi, Yulong Snow Mts | 27.0 | 100.1 | 5,596 | Glacial till | ESR | 530-430 ka | Zhao et al., 1999 |
| Penultimate- Guxiang Glaciations, 300-130 ka; MIS 6, Glacial extent 350,000 km ² ; concurrent with Gong'he Movement, greater than | Banzhuyuan- Shanshu-ping, Gongga Mts. | 29°36' | 101°53' | 3,470 | Glacial till | ESR | 277.1 ka | Zheng & Ma, 1994 |
| | Tianshuihai, W Kunlun Mts. | 35°32.968' | 79°31.821' | 4850 | Lake sediments | ESR | 240-17 ka | Li et al., 1998 |
| | Middle Terrace 40-60 m above Largen River, Damxung | 30°31' | 91°05' | 4,620 | Carbonate nodule of proglacial glaciofluvial sediments | ESR | 205±54 ka | Shi, 2006 |
| | East of Gangcha | E of Gangcha (| E of Gangcha | E of | Sand wedges | ESR | Quanji 229±20 ka; | Qi et al., 2014 |

| | | | | | | | | | |
|------|---|---|---|---|-------------------------------------|-----------------------------------|---------|--------------------------|-------------------------|
| | LLGM, with intensive pf development | and Quanji Village on N shore of Qinghai L | 37°15'43.7"); W of Quanji (37°14'22.2") | (100°00'28.4"); W of Quanji (99°50'13.0") | Gangcha (3238 m; W of Quanji 3235 m | | | Gangcha 197±18 ka | |
| | | Guxiang, East Nianqen Tanggula Mts. | 29°30' | 96°08' | 2,650 | Glacial till (MIS 6) | CRN10Be | 136.5±15.8~112.9±16.7 ka | Zhou et al., 2007 |
| | | Guxiang, E Nianqen Tanggula Mts. | 29°30' | 96°08' | 2,650 | Glacial till | ESR | 136.6±15.8 ka | Shi, 2006 |
| | | S of Guljin Glacier in Karakorums | 37° | 75° | 3,900 | Lake sediments | TL | 130.0±25.5 ka | Li et al., 1996a, 1996b |
| | | Tianshuihai, W Kunlun Mts. | 35°30' | 79°30' | 4,840 | Lacustrine calcerous silty sand | ESR | 137.0±24.8 ka | Li et al., 2006 |
| | | Ice wedge casts at Daheba, Xinghai, Qinghai | 35°50' | 99°40' | 3,350 | Wedge sands & gravels (fluvial) | ESR | 135.7±10.5 ka | Pan & Chen, 1997 |
| | | Yangsigezui, Zhungger, IMAR | 39°59' | 111°18' | 1,231 | Ice wedge casts in loess deposits | ESR | 132.0±13.0 ka | Zhou et al., 2008 |
| Late | Last Interglacial (MIS 5, 125-75 【 80-70】 ka) | Gulia ice core, W Kunlun Mts. | 35°15' | 80°30' | 6,700 | MIS 5e 冰芯, +5°C | | | Yao et al., 1997 |
| | | NE China Plain | | | | Lacustrine pollen records | | | Qiu, 1985 |

| | | | | | | | | | |
|--|--|---|------------|------------|-----------|-----------------------------------|------|---------------------------|--------------------------------------|
| | | E China (~43°N) | | | | Red-brown weathered crust | | | Liu, 1964 |
| | | E Eurasia | ~58° | 110°~140°E | | SLAP | | | Fotiev et al., 1974 |
| | | Central Siberia | ~56° | | | Ice wedge casts | | | Chen et al., 1990; Tong et al., 2014 |
| LLG Early Glacial (MIS 4: ca. 80/70-60 kaBP), 2nd intensive permafrost development | | Yangbajing R in W Nyenqen Yanggula Mts. | 30°10' | 91°31' | 4,550 | Glacial till | U-Th | 72.1±6.1 ka | Shi, 2006 |
| | | Headwater area of Urumqi River | 43°01' | 86°29' | 3,444 | Upper Wangfeng Moraines/Till | ESR | 72.0; 58.6; 56.6; 54.6 ka | Yi et al., 2001 |
| | | E of Maqu Horse Farm, Gansu | 33°47'1.8" | 102°08'17" | 3447 | Paleosol (293-298 cm) | OSL | 71.5±6.7 ka | He et al., 2020b |
| | | Uhai Basin, IMAR | 39.4° | 106.65° | 1050-1400 | Sand wedges | OSL | 66.45±7.08~62.69±6.81 ka | Li et al., 2016 |
| | | Muzhart Valley, Tianshan Mts. | 42°00' | 80°40' | 2,100 | Outside till of terminal moraines | ESR | 71.7~64.2 ka | Zhao et al., 2010a, 2010b |
| | | N Slope K3, QGL Peak | 36°10' | 77°01' | 4,730 | Lateral moraines | TL | 56.0~30.0 ka | Xu & Shen, 1995 |
| | | Maomao Hill, Tianzhu, Gansu | 37°14' | 103°10' | 2,540 | Lower & middle peat layers | 14C | >50.0 ka | Xu et al., 1984 |
| | | Tianshuihai | 35°32.968' | 79°31.821' | 4850 | Lake sediments | ESR | 240~17 ka | Li et al., 1998 |
| | | 2.5 km S of | 39°46'72" | 110°02'34" | 1,470 | Ice wedge casts | OSL | 57.9±7.4 ka | He et al., |

| | | | | | | | | | |
|------------------------------------|------------------------|---|-------------|--------------|-------|---------------------------------|-----|----------------------|------------------|
| | | Dongsheng, Ordos | | | | | | | 2020a |
| | | Service Station along NH 109 E Dongsheng, Ordos | 39°49'59" | 110°09'04" | 1,526 | Ice wedge casts | OSL | 51.5±1.4 ka (A type) | He et al., 2020a |
| | | 2 km S of Dongsheng, Ordos | 39°47'74" | 110°02'22" | 1,488 | Ice wedge casts | OSL | 51.2±4.9 ka | He et al., 2020a |
| | | East of Maqu Horse Farm, Gansu | 33°47'1.8" | 102°08'17" | 3447 | Paleosols (270~278 cm) | OSL | 49.8±4.3 ka | He et al., 2020b |
| | | Mt. Niutoushan at the west bank of the Ngöring Lake in the HAYR | 35°00'20.1" | 97°35'58.0" | 4304 | Ice wedge casts | OSL | 45.5±3.8 ka | He et al., 2020b |
| | | Younger till in Shaluli Glacial Remains, Daocheng, W Sichuan | 29.3821 | 100.0961 | 3800 | Red paleosol of weathered tills | ESR | 43.2 ka | Zhou & Li, 2003 |
| | | Shandan Horse Farm | 38°06'1.6" | 101°20'27.8" | 2891 | Ice wedge casts (2.4-2.6 m) | OSL | 42.9±4.0 ka | He et al., 2020b |
| LLG Interglacial (ca. 50-26 kaBP), | L Banner, Sunite, IMAR | | | | | Sandy polygons | | 45~ 41 ka | Li et al., 1994 |

| | | | | | | | | |
|------------------------|--|-------------|-------------|-------|--|-----|--------------------------|------------------------|
| permafrost degradation | N Terrace, Linxia, Gansu | 35°35' | 103°20' | 1,700 | Loess | TL | 50.00~40.91 ka | Pan & Xu, 1989 |
| | L Banner, Sunite, IMAR | | | | Sandy polygons | | 38~36 ka | Li et al., 1994 |
| | Maomao Hill, Tianzhu, Gansu | 37°14' | 103°10' | 2,540 | Buried pingo scars; uppermost peat layer | 14C | 50.0~31.1 ka | Xu et al., 1984 |
| | Huangchengzi, Menyuan, Qinghai | 37°38'25.2" | 101°9'43.3" | 3148 | Involutions | OSL | 30.0±2.5 ka | He et al., 2020b |
| | Huangchengzi, Menyuan, Qinghai | 37°38.4' | 101°5.7' | 3,148 | Involutions | OSL | 30.0±2.5 ka (110-130 cm) | Harris et al., 2017 |
| | Shabanliang, Datong, Shanxi | 40°01' | 113°50' | 1,150 | Sand wedges | 14C | 29.5±2.2 ka | Cui et al., 2002, 2004 |
| | Younger till in Shaluli Glacial Remains, Daocheng, W Sichuan | 29.3821 | 100.0961 | 3800 | Red paleosol of weathered tills | ESR | 27.5 ka | Zhou et al., 2003 |
| | E Donggang, Ordos | 39°49' | 110°04' | 1,460 | Ice wedge casts | 14C | 26.89±2.10 ka | Cui et al., 2002 |
| | 15 km S Uxin Banner, IMAR | 38°28' | 108°48' | 1,400 | Sand wedges | 14C | 33.44±2.54 ka | Cui et al., 2002, 2004 |
| | Baichengzi, IMAR | 38°15' | 108°40' | 1,300 | Involutions | 14C | 26.3±2.0 ka | Cui et al., 2002, 2004 |

| | | | | | | | | | |
|---|--|---|-------------|-------------|-------|--------------------------------|-----|--------------------------|---------------------------|
| | | Xubu, Datong, Shanxi | 40°01' | 113°41' | 1,100 | Sand wedges & involutions | TL | 26.0±2.0 ka | Yang et al., 1983 |
| | | Huangchengzi, Menyuan, Qinghai | 37°38.4' | 101°5.7' | 3,120 | Involutions | OSL | 26.0±2.0 ka (~6.2-6.5 m) | Vandenberghe et al., 2016 |
| | | Dongdagou, Datong, Shanxi | 40°01' | 113°40' | 1,100 | Involutions | 14C | 25.85±0.3 ka | Wang et al., 1989 |
| LLGM/LLPMax, MIS 2; c. 26-19 ka, very intensive pf dev, with coldest period at 23 ka, lowered by 9-10°C: QTP 6-9°C, Precip 30-70% (Shi YF, 2006), with glacial extent at 350,000 km ² (Li BY et al., 1991) | | Huangchengzi, Menyuan, Qinghai | 37°38.4' | 101°5.7' | 3,148 | Involutions | OSL | 24.0±1.8 ka (30-50 cm) | Harris et al., 2017 |
| | | Salaus, Jingbian, Shaanx | 37°40' | 108°28' | 1,290 | Sand & soil wedges, involution | 14C | 27.0~24.0 ka | Dong et al., 1985 |
| | | Huangchengzi, Menyuan, Qinghai | 37°38'25.2" | 101°9'43.3" | 3148 | Involutions | OSL | 24.0±1.8 ka | He et al., 2020b |
| | | Huangchengzi, Menyuan, Qinghai | 37°38.4' | 101°5.7' | 3,120 | Involutions | OSL | 23.0±2.0 ka (~5.5-6.0 m) | Vandenberghe et al., 2016 |
| | | West of Maqu Horse Farm, Gansu | 33°47'1.8" | 102°08'17" | 3447 | Ice wedge casts 2.6-2.7 m | OSL | 22.4±2.2 ka | He et al., 2020b |
| | | Yixing Logistics Park, N Dongsheng, Ordos, IMAR | 39°51'44" | 109°56'58" | 1,402 | Ice wedge casts | OSL | 22.4±2.0 ka | He et al., 2020a |

| | | | | | | | | |
|--|---------------------------------------|------------|--------------|-------|-----------------------------|-----|------------------------|--------------------------|
| | Huangchengzi, Menyuan, Qinghai | 37°38.4' | 101°5.7' | 3,120 | Involutions | OSL | 22.0±2.0 ka (~2.5-3 m) | Vandenberg et al., 2016 |
| | Baichengzi, Uxin Banner, IMAR | 37°59' | 108°49' | 1,152 | Involutions in humic silts | 14C | 22.380~21.670 ka; | Jin et al., 2016 |
| | Baichengzi, Uxin Banner, IMAR | 38°15' | 108°40' | 1,300 | Involutions | 14C | 21,260±907 a | Cui et al., 2002, 2004 |
| | Shandan Horse Farm | 38°06'1.6" | 101°20'27.8" | 2891 | Ice wedge casts (1.4-1.5 m) | OSL | 21.0±1.7 ka | He et al., 2020b |
| | Along NH 109 E Dongsheng, Ordos | 39°54'17" | 109°06'10" | 1,470 | Ice wedge casts | OSL | 20.6±2.1 ka | He et al., 2020a |
| | 2nd terrace Heihe R, Zoige, W Sichuan | 33°52' | 102°30' | 3,300 | Involutions | 14C | 20,340±550 a | Li et al., 2012 |
| | Huangchengzi, Menyuan, Qinghai | 37°38.4' | 101°5.7' | 3,148 | Involutions | OSL | 19.6±1.5 ka (50-70 cm) | He et al., 2020b |
| | Qiejitan, Gonghe, Qinghai | 36°17' | 101°09' | 3,100 | Sand wedges | 14C | 20,403~19,430 a | Chen & Pan, 1997 |
| | Anxi, Heixi Corridor | 41°00' | 96°00' | 2,600 | Sand wedges | 14C | 19,100±125 a | Wang et al., 2000 |
| | E bank of Golmud Reservoir, Qinghai | 36°08' | 94°50' | 3,100 | Loess on 3rd terrace | 14C | 18,931±400 a | Jin et al., 2006a, 2006b |

| | | | | | | | | | |
|-----------------------------|--|--|-------------|-------------|-----------|---------------------------------|------------|------------------------------------|--------------------|
| | | Highest dike of Lenghu, Qaidam | 38°40' | 93°15' | 3,200 | Sand wedges | 14C | 31,700~18,510 a | Ma, 1996 |
| Last Deglacial (19-12.9 ka) | | Younger till in Shaluli Glacial Remains, Daocheng, W Sichuan | 29.3821 | 100.0961 | 3800 | Red paleosol of weathered tills | ESR | 16.7 ka | Zhou & Li, 2003 |
| | | East side of Maqu Horse Farm, Gansu | 33°47'1.8" | 102°08'17" | 3447 | Lower sand layer (252-260 cm) | OSL | 16.6±1.6 ka | He et al., 2020b |
| | | Ronbusi on N slope of Zhomolongma | 28°11'42" | 86°49'41" | 4980-5100 | Terminal moraines | CRN OSR | 16.6±4.1, 14.2±0.9~16.32±0.8 ka | Owen et al., 2009 |
| | | Zhongning, Ningxia | 37°20' | 105°40' | 1,500 | Involutions | 14C | 17,480±1,250 a | Zhang et al., 2000 |
| | | Xiangpishan W of Qinghai L | 36°42' | 99°30' | 1,500 | Involutions | 14C | 17,480±1,250 a | Zhang et al., 2000 |
| | | W Dongsheng, Ordos | 39°49' | 109°50' | 1,460 | Sand wedges | 14C | 16,900±1,300 a | Cui et al., 2004 |
| | | 2nd terrace Zuomoxikongqu, Fenghuo, QTP | 34°40' | 92°50' | 4,700 | Sand wedges | 14C | 23,500~16,340 a | Guo, 1979 |
| | | Mt. Niutoushan at W bank of Ngöring Lake in the HAYR | 35°00'20.1" | 97°35'58.0" | 4304 | Ice wedge casts | OSL | 16.3±1.2 ka | He et al., 2020b |

| | | | | | | | | |
|--|--|------------|------------|-------|---------------------------------------|-----|-----------------|--------------------------------------|
| | S Mt Xingxinghai, Madoi, Qinghai | 34°30' | 98°10' | 4,350 | Sand wedges | 14C | 16,340~12,300 a | Pan & Chen, 1997 |
| | Xupu, Datong, Shanxi | 40°01' | 113°41' | 1,100 | Frost cracks | 14C | 15,800±1,300 a | Cui et al., 2002 |
| | Tongtian R, S Qumaleb, Qinghai | 34°02' | 95°52' | 4,170 | Loess on 3rd terrace | 14C | 15,377±292 a | Jin et al., 2006a, 2006b |
| | 2nd terrace Kunlun R, Nachitai, Qinghai | 35°40' | 94°20' | 3,580 | Sand & soil wedges | 14C | 15,337 a | Wang, 1989 ; Wang & Bian, 1993 |
| | East of Maqu Horse Farm, Gansu | 33°47'1.8" | 102°08'17" | 3447 | Sand wedges (187-193cm) | OSL | 15.1±0.8 ka | He et al., 2020b |
| | Zinihu, W of Helan Mts. | 39°10' | 106°00' | 1,350 | Involutions | 14C | 25.0~15.0 ka | Shan, 1997 |
| | 2nd terrace Heihe R, Zoige, W Sichuan | 33°52' | 102°30' | 3,300 | Involutions | 14C | 14,770±240 a | Li et al., 2012 |
| | Outlet of Zashitang Valley, Zoige | 33°54' | 102°35' | 3,300 | Involutions in silts and fine sand | 14C | 14,710±340 a | Li et al., 2012 |
| | Xinzaizi Brick Factory | 35°45.137' | 108°9.405' | 1370 | Sand-wedge | OSL | 14,500±800 a | He et al., 2020a |
| | Huanghe Village, | 34°35' | 98°52' | 4,300 | Ice wedge casts | TL | 13,490±1,430 a | Guo, 1979 |

| | | | | | | | | |
|---|---|-------------|------------|-------|----------------------------|---------|-----------------------|--------------------------|
| | Madoi, Qinghai | | | | | | | |
| | Huanghe Village, Madoi, Qinghai | 34°36'10.8" | 98°23'0.8" | 4214 | Ice wedge casts | OSL | 13.3±1.1; 12.5±1.0 ka | He et al., 2020b |
| | Sand dunes N Wudaoliang, QTH | 35°20' | 93°07' | 4,680 | Humus layer | 14C | 12,700±820 a | Jin et al., 2006a, 2006b |
| | Road S NH 109, NE of Dongsheng, Ordos | 39°47' | 110°09' | 1,526 | Sand & soil wedges | TL | 17,900~11,600 a | Jin et al., 2016 |
| | Yangyuan, Hebei | 40°10' | 114°15' | 900 | Sand wedges, involutions | 14C | 27.0~11.0 ka | Zhang et al., 1984 |
| Younger Dryas Glacial Advance (12,900-11,700 a) | Gulia ice cap, W Kunlun Mts. | 35°30' | 79°30' | 4,840 | Ice core | 冰芯 | 12,200-10,800 a | Yao et al., 1997 |
| | Service Station along the 109 E of Dongsheng, Ordos, IMAR | 39°49'59" | 110°09'04" | 1,526 | Ice wedge casts | OSL | 11,600±600 a (B type) | He et al., 2020a |
| | Tianshuihai, Kunlun Mts. | 35°32' | 79°31' | 4,847 | Sand wedges | 14C | 13,888~11,533 a | Chang et al., 2011, 2017 |
| | Daxueshan, near Kangding, W Sichuan | | | | Suspected glacial boulders | CRN10Be | 11,590±490 a | Tschudi et al., 2003 |
| | Zepu Glacier, E Nian-qen Tanggula Mts. | | | | Terminal moraines | 14C | 11,252±200 a | Jiao & Iwahata, 1993 |

| | | | | | | | | | |
|-----------------------|--|---|------------|--------------|-------|--------------------------------------|-----|--------------------------|--------------------------|
| | | 2.5 km from Conce Ice cap terminal | | | | Terminal moraines | 14C | 11,087±198 a | Jiao et al., 2000 |
| | | Zhuolu, Hebei | 40°20' | 115°10' | 800 | Involutions | 14C | 11,030±150 a | Huang & Huang, 1988 |
| | | Xinzaizi, Eqian Banner, Ordos | 37°45' | 108°09' | 1,332 | Sand wedges in silts and sandy clays | TL | 14,500~11,000 a | Jin et al., 2016 |
| | | E of Maqu Horse Farm, Gansu | 33°47'1.8" | 102°08'17" | 3447 | Sand wedges (depths at 187-193cm) | OSL | 10.7±0.8 ka | He et al., 2020b |
| | | Wuma, Da Xing'anling Mts. | 52°45' | 125°45' | 350 | Inactive ice wedges | 14C | 14,475~10,653 a | Tong, 1993 |
| | | Outside of north and east iceflows in the Gulia Ice Cap | 35°30' | 79°30' | 4,840 | Terminal moraines | 14C | 10,900±190; 10,533±123 a | Jiao et al., 2000 |
| Holocene (<11.7 kaBP) | Early Holocene of dramatic climate changes (11.7~8.5-7.0 ka), stable permafrost but relatively degrading | Shandan Horse Farm | 38°06'1.6" | 101°20'27.8" | 2891 | Ice wedge casts (0.65-0.75 m) | OSL | 10.3±0.8 ka | He et al., 2020b |
| | | Wumaqu, Damxung | 30°30' | 91°25' | 4,600 | Involutions | 14C | 9,970±135 a | Jin et al., 2006a, 2006b |
| | | Sand ridge 2 km SE of Wudaoliang, QTH | 35°19' | 93°08' | 4,680 | Plant stems/roots | 14C | 9,716±270 a | Jin et al., 2006a, 2006b |
| | | HMSS 82, S | 34°40' | 92°45' | 4,800 | Sand wedges | 14C | 9,160±170 a | Jin et al., |

| | | | | | | | | |
|--|--|-------------|------------|-------|--|-----|---------------------------|-----------------------------|
| | Fenghuo Mts., QTH | | | | | | | 2006a |
| | Zuomoxikongqu, Fenghuo Mts., QTH | 34°40' | 92°50' | 4,700 | Humic sands at upper sand wedges | 14C | 9,160±170 a | Jin et al., 2006a |
| | W of road 2 km from Dongsheng | 39°47.735' | 110°2.224' | 1488 | Sand-wedge | OSL | 8,900±2,100 a | He et al., 2020a |
| | Borehole CK80-3 Qingshuihe, QTH | 35°29' | 93°30' | 4,570 | Silty clay | 14C | 8,800±305 a | Jin et al., 2006a, 2006b |
| | Huanghe Village, Madoi | 34°36'10.8" | 98°23'0.8" | 4214 | Ice wedge casts | OSL | 8.7±0.7; 7.8±0.9 ka | He et al., 2020b |
| | Yitala Terr, Gonghe | 36°12' | 100°30' | 3,300 | Involutions | 14C | 7,890±185; 8,350±100 a | Xu et al., 1984 |
| | Shazhuyukou, Qaidam | 36°20' | 100°10' | 2,900 | Involutions | 14C | 7,750±90 a | Xu et al., 1984 |
| | Dongsheng, Ordos | 39°49' | 110°04' | 1,460 | Sand wedges | 14C | 7,050±540 a | Cui et al., 2004 |
| Mid-Holocene Megathermal Period (HMP, 8.5-7.0~4.0-30 ka, intensive permafrost degradation) | 2nd terr, Heihe R, Zoige | 33°52' | 102°30' | 3,300 | Silt involutions | 14C | 6,900±275 a | Li et al., 2012 |
| | Huihe Forest Farm, S Hulun Buir | 48°04' | 119°37.7' | 779 | Soil wedges, peat & Fine sands | 14C | 7,688±43; 5,214±29 a | Jin et al., 2011, 2019 |
| | Zhaxigaitang Val. Zoige | 33°54' | 102°35' | 3,300 | Involution in silts | 14C | 8,860±200 a | Li et al., 2012 |
| | Dahewan | 40°20' | 114°58' | 850 | Sand wedges | 14C | 7,590±580 a | Cui et al., |

| | | | | | | | | |
|---|---|-----------|------------|---------------|--------------------------|-----|---------------------------|-----------------------------|
| | Terrace, IMAR | | | | | | | 2002 |
| | 4.4 m in BH 8# Xidatan | 35°45' | 94°15' | 4,400 | Peat layer | 14C | 7,530±300 a | Jin et al., 2006a, 2006b |
| | RH Borehole lake sediments, Zoigé | 33°54.27' | 102°32.70' | 3396 | Picea & Abies; +1~2°C | 14C | 7000-5000 | Shen et al., 1996 |
| | Uhai, IMAR | 39.4° | 106.65° | 1050- 1400 | Ice wedge casts | OSL | 6.62±0.73~5.95±0.61 ka | Li et al., 2016 |
| | Ximenco, Nianboyeze | 33°25' | 101°07' | 4,300 | Peat layer | 14C | 5,422±94 a | Li et al., 2012 |
| | N of HMSS 109 QTH | 32°48' | 91°55' | 4,900 | Thick humus | 14C | 5,058±443 a | Jin et al., 2006a, 2006b |
| | Gully on Heka S Mts. | 35°48' | 99°56' | 3,520 | Thick humus | 14C | 4,625±117 a | Jin et al., 2006a |
| | N of HMSS 120 QTH | 31°59' | 91°48' | 4,660 | Thick humus | 14C | 4,576~4,363 a | Jin et al., 2006a |
| | Riyue Mt Pass, Qinghai | 36°20' | 101°06' | 3,600 | Paleosols | 14C | 4,292±80 a | Wang, 1989 |
| | Hongyuan Peat farm, Zoige | 32°50' | 102°30' | 3,500 | Thick peat | 14C | 6,250~3,250 a | Jin et al., 2006a |
| Late Holocene Neoglaciation (4000-3000~1000 a), significant glacial & pf expansion | Upper sand dunes E bank of Qinghai Lake | 36°30' | 100°40' | 3,232 | Paleosols | 14C | 3,960±100 a | Jin et al., 2006a |
| | Pingo scars in Shiqu, Sichuan | 32°58' | 98°15' | 4,100 | Humic silt & sands | 14C | 3,295±175 a | Jin et al., 2006a |
| | Qinongga peat valley at | 30°08' | 91°40' | 4,630 | Involutions | 14C | 3,270±70 a | Jin et al., 2006a |

| | | | | | | | | | |
|---|---|----------------|---------------|-----------------|---|-----|---------------------------------|-------------------------------|--|
| | Yangbajing | | | | | | | | |
| | Huangchengzi, Menyuan, Qinghai | 37°38.4' | 101°5.7' | 3,120 | Involutions | OSL | 2,700±400 a (top ~1 m) | Vandenberg he et al., 2016 | |
| | S of Yitulihe, E IMAR | 50°32' | 121°29' | 730 | Inactive ice weges inhumic calyey soils on 1st terrace | 14C | 3,644~2,388 a | Peng & Cheng, 1990 | |
| | 2nd terrace, Heihe R, Zoige | 33°52' | 102°30' | 3,300 | Involutions in silts | 14C | 2,440±95 a | Li et al., 2012 | |
| | Huihe Forest Farm, S Hulun Buir, E IMAR | 48°04' | 119°37.7' | 779 | Soil wedges, peat & fine sands | 14C | 2,992±30; 1,347±24 a | Jin et al., 2011 | |
| | Pingo scars E Changmahe, Maqen, Qinghai | 34°38' | 99°25' | 4,100 | Humic clayey soils | 14C | 3,927~628 a | Jin et al., 2006a | |
| Medieval Warm Period (MWP, 1000~500 a), relative pf degradation | Top of pingo scars at E part of Xidatan | 35°42' | 94°25' | 4,250 | Silty sandy clay | 14C | 720±39 a | Jin et al., 2006a | |
| Little Ice Age (LIA, 500~100 a), relative permafrost expansion | Headwater area of Urumqi River | 43°04' -43°08' | 86°48'-87°00' | 2,900- 4,300 | Terminal moraines | | AD 1538±20; 1777±20; 1871±20 | Chen, 1989 | |



[

*Notes: ESR—Electron spin resonance; TL-- Thermoluminescence, OSL--Optically stimulated luminescence, CRN--Cosmogenic radionuclide.

** Latest CRN dating of glacier ice from the Gulia Ice-cap in the West Kunlun Mountains on the QTP by Professor Lide Tian indicates a much younger age of the terminal ice at ca. 50 ka BP.

References

- An Z, Wei L, 1980. The fifth layer paleosol in the Lishi loess and their paleoclimatic significance (in Chinese). *Acta Pedologica Sinica*, 17(1): 1-10.
- Cao B, Tian M, Li C, 1989. New discovery of strata of 730-900 ka BP in Zhoukoudian area in Beijing and preliminary studies on its paleo-ice-wedge casts (in Chinese). *Chinese Sci Bull*, 34(7): 530-533.
- Chang X, Jin H, He R, 2011. Formation and environmental evolution of sand wedges on the Tianshuihai North Lakeshore in the western Kunlun Mountains. *Quat Sci*, 31(1): 112-119 (in Chinese).
- Chang X, Jin H, He R, Lü L, Harris SA, 2017. Evolution and changes of permafrost on the Qinghai-Tibet Plateau during the Late Quaternary. *Sci Cold Arid Regions*, 9(1): 1-19.
- Chen J, 1989. Preliminary researches on lichenometric chronology of Holocene glacial fluctuations and on other topics in the headwater of Urumqi River, Tianshan Mountains. *Sci China: Series B*, 32(12): 1487-1500.
- Chen H, Guan K, Yan Z, 1990. [Discovery and significance of frost driving structure at the ice-front of Quaternary on Zhongxiang District, Hubei Province (in Chinese). *Geosci-J Graduate School, China Univ Geosci*, 4(2): 92-98.
- Cui Z, Wu Y, Liu G, 1998. Records of natural exposures on the Kunlun Shan Pass of Qinghai-Xizang highroad//Shi Y, Li J, Li B, eds., *Uplift and Environmental Changes of Qinghai-Xizang (Tibetan) Plateau in the Late Cenozoic* (in Chinese). Guangzhou: Guangdong Science and Technology Press: 81-114.
- Cui Z, Zhao L, Vandenberghe J, Zhang W, 2002. Discovery of ice wedge and sand-wedge networks in Inner Mongolia and Shanxi Province and their environmental significance (in Chinese). *J Glaciol Geocryol*, 24(6): 708-717.
- Cui Z, Yang J L, Zhao L, Zhang W, Xie Y, 2004. Discovery of a large area of ice-wedge networks in Ordos: Implications for the southern boundary of permafrost in the north of China as well as for the environment in the latest 20 ka BP. *Chinese Sci Bull*, 49: 1177-1184.
- Dong G, Li B, Gao S, Wu Z, 1985. The phenomenon of fossil ice margins and its significance in climatic stratigraphy in the Ordos Plateau (in Chinese). *Geogr Res*, 4(1): 1-13.
- Fotiev SM, Danilova NS, Sheveleva NS, 1974. *Geocryological conditions in Central Siberia* (in Russian). Moscow, Science Press, 98-105. Tong B (translated), 2016. *Principles of Geocryology* (in Chinese), Vol 3: *Regional History of Geocryology*. Lanzhou: Lanzhou University Press, 55-63.
- Gravis GF, Zabolotnik SI, Sukhodrovsky VL, Gavrilova MK, Lisun AM (eds), 1974. Major stages of permafrost. In: *Geological conditions of Mongolia Republic*. Moscow, Nauka (Science) Press, 184–186 (in Russian).
- Guo D, 1979. Sand wedges on the Qinghai-Tibet Plateau. *J Glaciol Cryopedol(Geocryol)*,

1(1): 51-53 (in Chinese).

- Guo Z, Yao X, Zhao X, *et al.*, 2001. A tropical paleosol at high elevation in the Yulong Mountains and its implication on the uplift of the Tibetan Plateau. *Chinese Sci Bull*, 46(1): 69-72.
-
- Guo Z, Ruddiman WM, Hao Q, *et al.*, 2002. Onset of Asian desertification by 22 Myr ago inferred from loess deposits in China. *Nature*, 2002, 416: 159- 163.
- Harris SA, Jin H, He R, 2017. Very large cryoturbation structures of last Permafrost Maximum age at the foot of Qilian Mountains (NE Tibet Plateau, China): A discussion. *Permafrost Periglacial Process*, 27: 138-141.
- He R, Jin H, French HM, Vandenberghe J, Li X, Jiang G, Zhang Z, Chen X, Serban DR, Wang S, Guo D, 2020a. Cryogenic wedges and cryoturbations on the Ordos Plateau in North China since 50 ka BP and their paleo-environmental implications. *Permafrost Periglacial Process*, DOI: 10.1002/ppp.2084.
- He R, Jin H, Harris SA, Luo D, Chen X, Jin X, Wang Q, Lu L, Wang S, 2020b. Permafrost and paleoenvironment on the northeastern Qinghai-Tibet Plateau in Southwest China during the Last Glacial Maximum (LGM). *J Quat Sci*, in revision.
- Huang B, Huang X, 1988. Relationship Between Ostracoda and Marginal Glacial Deposits of Upper Pleistocene in Sanggan River (in Chinese). *J Glaciol Geocryol*, 10(4): 429-434
- Jiao K, Iwata S, 1993. Glacial changes since the last glaciation in Kunlun Pass, Tanggula Pass and southeast Xizang (Tibet)// Yao T, Ageta Y *et al.* *Glaciological Climate and Environment on Qing-Zang Plateau*. Beijing: Science Press: 120-129.
- Jiao K, Yao T, Li S, 2000. Glacier variations on the south slope of West Kunlun Mountains since 30000 years (in Chinese). *J Glaciol Geocryol*, 22(3): 250-256.
- Jin H, Zhao L, Wang S, Guo D, 2006a. Evolution of permafrost and environmental changes of cold regions in eastern and interior Qinghai-Tibetan Plateau since the Holocene (in Chinese). *Quat Sci*, 26: 198-210.
- Jin H, Zhao L, Wang S, Jin R, 2006b. Thermal regimes and degradation modes of permafrost along the Qinghai-Tibet Highway. *Sci China*, 49(D11): 1170-1183.
- Jin H, Luo D, Wang S, Lü L, Wu J, 2011. Spatiotemporal variability of permafrost degradation on the Qinghai-Tibet Plateau. *Sci Cold Arid Regions*, 3(4): 281-305.
- Jin H, Chang X, He R, and Guo D, 2016. Evolution of permafrost and periglacial environments in Northeast China since the Last Glaciation Maximum. *Sci Cold and Arid Regions*, 8(4): 269-296. doi: 10.3724/SP.J.1226.2016.00269
- Jin H, Jin X, He R, Luo D, Chang X, Wang S, Marchenko SS, Yang S, Yi C, Li S, Harris SA, 2019. Evolution of permafrost in China during the last 20 ka. *Sci China, Ser D: Earth Sci*, 62(8): 1181-1192. <https://doi.org/10.1007/s11430-018-9272-0>
- Li B, Zhang Q, Wang F, 1991a. Lake evolution in Karakorum and West Kunlun Mountains(in Chinese). *Quat Sci*, 21(1): 64-71.
- Li J, Feng Z, Kang J, 1996a. Glacial deposits and environment in the Hengduan Mountains (in Chinese). In: Li JJ, Su Z edited, *Glaciers in the Hengduan Mountains*. Beijing: Science Press, pp. 157-173.
- Li J, Fang X, Ma H, *et al.*, 1996b. Geomorphological and environmental evolution in the upper reaches of the Yellow River during the late Cenozoic. *Sci China: Ser D, Earth Sci*, 39(4): 380-390

- Li L, Chi Z, Zhao G, Gao D, Geng M, Li S, 1994. A study on cryogenic in Middle Inner Mongolia (in Chinese). *Earth Sci—J China Univ Geosci*, 19(2): 257-261.
- Li S, Ou R, Zhu Z, Li B, 1998. A 240 ka carbonate content record of Late Quaternary climate and environment changes from lacustrine core TS95 in Tianshuihai Lake Basin, northwestern Qinghai-Xizang (Tibet) Plateau (in Chinese). *J Lake Sci*, 10(2): 58-65.
- Li S, Cheng W, Jiang Y, Jin C, Li C, Luo R, Wang X, 2012. Geological records for Holocene climatic and environmental changes derived from glacial, periglacial and lake sediments on Qinghai-Tibetan Plateau (in Chinese). *Quat Res*, 32(1): 151-156.
- Li D, Li D, Shen X, Sun C, Kang Y, Zhang Y, 2016. Discovery of sand wedge/ice wedge cast of Last Glaciation in Wuhai Basin and its paleoclimatic significance (in Chinese). *J Earth Sci Environ*, 38(3): 410-419.
- Liu D, 1964. Loesses in the middle streams of the Yellow River. Beijing: China, Science Press.
- Liu G, Shen Y, Zhang P, *et al.*, 1994 Pollen record and its palaeoclimatic significance between 800-150 ka BP from RH-core in Zoige Basin in Qinghai-Xizang (Tibet) Plateau (in Chinese). *Acta Sedimentologica Sinica*, 12 (4): 101-109.
- Ma H, 1996. *Studies on terraces of the Chaidam basin, and Huangshui and Huanghe (Yellow) rivers* (in Chinese). Doctoral Dissertation. Lanzhou: Lanzhou University, 32-33.
- Owen LA, Robinson R, Benn DI, *et al.*, 2009. Quaternary glaciation of Mount Everest. *Quat Sci Rev*, 28 (15/16): 1412-1433.
- Pan B, Xu S, 1989. Discussions on the evolution of natural environment on eastern Qinghai Plateau during the Late Quaternary (in Chinese). *Chinese Sci Bull*, 34(7): 534-536.
- Pan B, Chen F, 1997. Permafrost evolution in the northeastern Qinghai-Tibetan Plateau during the last 150,000 years (in Chinese). *J Glaciol Geocryol*, 19: 124-132.
- Peng H, Cheng G, 1990. Ice wedges in the Da Xing'anling Mountains and their paleoclimatic implications (in Chinese). In: *Collection Papers of Chinese Conference on Glaciology and Geocryology (Geocryology Volume)*. Beijing: Science Press, 9-16
- Qi B, Hu D, Zhao X, Zhang X, Zhang Y, Yang X, Zhao Z, Gao X, 2014. Fossil sand wedges in the northern shore of Qinghai Lake: Discovery and paleoclimatic implications (in Chinese). *J Glaciol Geocryol*, 36: 1412-1419.
- Qiu S, 1985. Basic features of natural environments in Northeast China Plain during the Pleistocene (in Chinese). In: *Collection of Papers presented in the Conference on Quaternary Glacial and Periglacial Landforms in China*. Beijing: Science Press, 208-211.
- Shan P, 1997. Periglacial landform process and its environmental changes in the Zinihu region at the western side of the Helan Mountains since the Late Pleistocene (in Chinese). *Geol Rev*, 43(4): 428-433.
- Shen C, Tang L, Wang S, 1996. Vegetation and climate during the last 250,000 years in Zoige region (in Chinese). *Act Micropalaeontol Sin*, 13(4): 373-385.
- Shi Y, 2006. *Quaternary Glaciers in China and Environmental Changes* (in Chinese). Beijing: Science Press. 134-138.
- Sun J, 1981. Quaternary periglacial stages on the Songliao Plain (in Chinese). *Scientia Geographica Sinica*, 1(2): 163-170.

- Sun J, Zhang Z, Ai K, Liu Y, Li D, Yuan W, 2007. Quaternary strata systems on the Songliao Plain (in Chinese). In: Sun J, Zhang Z, edited, *Quaternary History on the Songliao Plain, China*. Hong Kong: China Review Academic Publisher Limited, pp. 1-53.
- Thompson LG, Yao T, Davis ME, *et al.*, 1997. Tropical climate instability: The Last Glacial Cycle from a Qinghai-Tibetan ice core. *Science*, 276: 1821-1825.
- Thompson LG, Mosley-Thompson E, Davis ME, *et al.*, 2006 Ice core evidence for asynchronous glaciation on the Tibetan Plateau. *Quat Int*, 154/155: 3-10.
- Tong B, 1993. Ice wedges in Northeast China (in Chinese). *J Glaciol Geocryol*, 15: 41-46
- Tong H, Wang F, Zheng M, Chen X, 2014. New discoveries of fossils on the *Stephanorhinus kirchbergensis* and *Elasmotherium peii* in the Nihewan Basin, Hebei, China (in Chinese). *Acta Anthropologica Sinica*, 33(3): 369-389.
- Tschudi S, Schäfer JM, Zhao Z, *et al.*, 2003. Glacial advances in Tibet during the Younger Dryas? Evidence from cosmogenic ^{10}Be , ^{26}Al , and ^{21}Ne . *J Asian Earth Sci*, 22(4): 301-306.
- Vandenberghe J, Wang X, Vandenberghe D, 2016. Very large cryoturbation structures of Last Permafrost Maximum age at the foot of the Qilian Mountains (NE Tibet Plateau, China). *Permafrost Periglacial Process*, 27: 138-143.
- Wang S, 1989. Formation and evolution of permafrost on the Qinghai-Xizang Plateau since the Late Pleistocene (in Chinese). *J Glaciol Geocryol*, 11: 67-75
- Wang S, Bian C, 1993. The involutions and their palaeoclimatic significance in the Nachitai region along the Qinghai-Xizang Highway (in Chinese). *Geogr Res*, 132: 94-100
- Wang N, Yang J, Xia Z, Mo D, Li Y, Pan M, 1989. *Cenozoic deposits and tectonic geomorphology of Shanxi Graben Basin* (in Chinese). Beijing: Science Press, p. 52.
- Wang N, Wang T, Gao S, Shi Z, Hu G, 2000. The Sand wedge and mirabilite of the Last Ice Age and paleoclimatic reconstruction in Hexi Corridor, Gansu, West China (in Chinese). *Earth Sci Front (China Univ Geosc Beijing)*, 7(Suppl): 59-66.
- Wang J, Raisbeck G, Xu X, *et al.*, 2006. In situ cosmogenic ^{10}Be dating of the Quaternary glaciations in the southern Shaluli mountain on the southeastern Tibetan Plateau. *Sci China, Series D: Earth Sci*, 49(12): 1291-1298.
- Wu Z, Zhao X, Jiang W, *et al.*, 2003. Dating result of the Pleistocene glacial deposits on the southeast foot of Nyaiqentanglha Mountains (in Chinese). *J Glaciol Geocryol*, 25(3): 272-274.
- Xu D, Shen Y, 1995. On ancient ice-sheet and ice age in the Tibetan Plateau (in Chinese). *J Glaciol Geocryol*, 17(3): 213-229.
- Xu S, Zhang W, Xu D, Xu Q, Shi S. 1984. Discussion on the periglacial development in the northeast margin regional of Qinghai-Xizang Plateau (in Chinese). *J Glaciol Geocryol*, 6: 15-24
- Yang J, li S, Sun J, Wang Y, 1983. Fossil ice wedges and Late Pleistocene environment in Datong Bain, Shanxi Province (in Chinese). *Sci Geogr Sinica*, 3(4): 339-344.
- Yao T, Thompson LG, Shi Y, Jiao K, Yang Z, Tian L, Thompson ME, 1997. Climate variations since the Last Interglacial recorded in the Guliya ice core. *Sci China, Ser D: Earth Sci*, 40(6): 662-668.

- Yi C, Jiao K, Liu K, 2001. ESR dating on tills and the Last Glaciation at the Headwaters of the Ürumqi River, Tianshan Mountains, China (in Chinese). *J Glaciol Geocryol*, 23(4): 389-393.
- Yi C, 2018. Progresses, problems and study trend in geochronology and other fields of Quaternary glaciations (in Chinese). *Quat Sci*, 38(3): 537-561.
- Zhang L, 1984. Reconstruction of the climate of Late Pleistocene Ice Age in China (in Chinese). *J Beijing Normal Univ Nat Sci*, 1: 101-118.
- Zhang K, Liu K, Yang J, 2000. The discovery and its significance of Late Quaternary involution in the area of lower reach of Qingshuihe River, Ningxia, China (in Chinese). *Acta Scient Natural Universit Pekinesis*, 36(5): 714-718.
- Zhao X, Qu Y, Li T, 1999. Pleistocene glaciations along the eastern foot of the Yulong Mountains (in Chinese). *J Glaciol Geocryol*, 21(3): 242-248.
- Zhao X, Wu Z, Zhu D, *et al.*, 2002. Quaternary glaciations in the west Nyaiqentanglha Mountains (in Chinese). *Quat Sci*, 22(5): 424-433.
- Zhao J, Zhou S, He Y, *et al.*, 2006. ESR dating of glacial tills and glaciations in the Urumqi River headwaters, Tianshan Mountains, China. *Quat Int*, 144: 61-67
- Zhao J, Liu S, He Y, *et al.*, 2009a. Quaternary glacial chronology of the Ateaoynake River Valley, Tianshan Mountains, China. *Geomorphology*, 103(2): 276-284.
- Zhao J, Wang J, Shangguan D, 2009b. Sequences of the Quaternary glacial sediments and their preparatory chronology in the Tumor River valley, Tianshan Mountains (in Chinese). *J Glaciol Geocryol*, 31(4): 628-633.
- Zhao J, Liu S, Wang J, *et al.*, 2010a. Glacial advances and ESR chronology of the Pochengzi Glaciation, Tianshan Mountains. *Sci China, Ser D, Earth Sci*, 53(3): 403-410.
- Zhao J, Song Y, King JW, 2010b. Glacial geomorphology and glacial history of the Muzart River valley, Tianshan range, China. *Quat Sci Rev*, 29(11/12): 1453-1463.
- Zheng B, 2000. Quaternary Glaciations and their evolution patterns in Yulong Shan (Chinese). *J Glaciol Geocryol*, 22(1): 53- 61.
- Zheng B, Shi Y, 1976. Study on Quaternary glaciations in the Everest area//Comprehensive Scientific Expedition to the Tibetan Plateau, CAS. *Scientific Expedition Report of the Everest Area (1966-1968): Quaternary Geology*. Beijing: Science Press: 29-62.
- Zheng B, Ma Q, 1994. The glacier variation, climate change and the river valley development in the Holocene on the Gongga Mountains (in Chinese). *Act Geogr Sin*, 49(6): 500-507.
- Zheng B, Xu Q, Shen Y, 2002. The relationship between climate change and Quaternary glacial cycles on the Qinghai-Tibetan Plateau: Review and speculation. *Quat Int*, 97/98: 93-101.
- Zhou S, Li J, 2003. New dating results of Quaternary glaciations in China (in Chinese). *J Glaciol Geocryol*, 25(6): 660-606.
- Zhou Y, Qiu G, Cheng G, Guo D, Li S, 2000. *Geocryology in China* (in Chinese). Beijing: Science Press. 366-388.
- Zhou S, Yi C, Shi Y, *et al.*, 2001a. Study on the ice age MIS 12 in western China. *J Geomech*, 7(4): 321-327.

- Zhou S, Li J, Zhang S, 2002a. Quaternary glaciation of the Bailang River Valley, Qilian Shan. *Quat Int*, 97/98: 103-110.
- Zhou S, Xu L, Cui J, *et al.*, 2005. Geomorphologic evolution and environmental changes in the Shaluli Mountain region during the Quaternary. *Chinese Sci Bull*, 50(1): 52-57.
- Zhou S, Xu L, Colgan PM, *et al.*, 2007. Cosmogenic ^{10}Be dating of Guxiang and Baiyu glaciations. *Chinese Sci Bull*, 52(10): 1387-1393.
- Zhou T, Pan B, Liu X, Su H, Hu Z. 2008. The discovery of ice-wedge casts in Erdos: Rebuilding the permafrost boundary during the Penultimate Glaciation in China (in Chinese). *J Glaciol Geocryol*, 30(1): 108-112.
- Zhu D, Meng X, Shao Z, Yang C, Han J, Yu J, Meng Q, Lü R, 2006. Early Pleistocene deposits and paleoclimatic and paleoenvironmental changes in the Zanda basin, Ngari area, Tibet. *Geol China*, 33(6): 1276-1284 (in Chinese).