Journal of Mountain Science Vol **4** No 2 (2007): 091~123
http://jms.imde.ac.cn

DOI: 10.1007/s11629-007-0091-7

Critical Approach to Methods of Glacier Reconstruction in High Asia and Discussion of the Probability of a Qinghai-Xizang (Tibetan) Inland Ice

Matthias Kuhle

Geographie/ Hochgebirgsgeomorphologie, Geographisches Institut der Universität, Goldschmidtstr.5, 37077 Göttingen, Germany

E-Mail: mkuhle@gwdg.de.

Abstract: This overview discusses old and new results as to the controversy on the past glacier extension in High Asia, which has been debated for 35 years now. This paper makes an attempt to come closer to a solution. H.v. Wissmann's interpretation (1959) of a small-scale glaciation contrasts with M. Kuhle's reconstruction (1974) of a large-scale glaciation with a 2.4 million km² extended Qinghai-Xizang (Tibetan) inland glaciation and a Himalaya-Karakorum icestream network. Both opinions find support but also contradiction in the International and Chinese literature (Academia Sinica). The solution of this question is of supraregional importance because of the subtropical position of the concerned areas. In case of large albedo-intensive ice surfaces, a global cooling would be the energetical consequence and, furthermore, a breakdown of the summer monsoon. The current and interglacial heat-low above the very effective heating panel of the Qinghai-Xizang (Tibetan) Plateau exceeding 4000 m, which gives rise to this monsoon circulation, would be replaced by the cold-high of an inland ice. In addition, the plate-tectonically created Pleistocene history of the uplift of High Asia — should the occasion arise up to beyond the snowline (ELA) — would attain a paleoclimatically great, perhaps global importance. In case of a heavy superimposed ice load, the question would come up as to the glacio-isostatic interruption of this primary uplift. The production of the loesses sedimentated in NE-China and their very probable glacial genesis as well as an eustatic lowering of the sea-level by 5 to 7 m in the maximum case of glaciation are immediately tied up with the question of glaciation we want to discuss. Not the least, the problems of biotopes of the sanctuary-centres of flora and fauna, i.e., interglacial re-settlement, are also dependent on it. On the basis of this Quaternary-geomorphological-glaciological connection, future contributions are requested on the past glaciation, the current and glacial permafrost table and periglacial development, the history of uplift, and the development of Ice Age lakes and loess, but also on the development of vegetation and fauna in High Asia.

Keywords: Approach; methods; inland ice; glacier reconstruction; High Asia; Qinghai-Xizang (Tibetan)

Received: 19 April 2007
Accepted: 26 April 2007

Note: The study area of this paper covers Qinghai-Xizang (Tibet) Plateau, West Sichuan Plateau, Himalaya, Karakorum, Pamir, Kuenlun, Tienshan.

The space available here for an overview as to the state of research of the glacier reconstruction in High Asia and a critical approach to the methods which have been applied, demands an exemplary evaluation of glacier research. To this naturally belongs a report on important positions with regard to an Ice Age glacier cover and their classification into the global Ice Age concept. As to the method as well as to the empirical findings, only prominent examples can be cited and discussed in place of a great number of individual publications. Accordingly, this has to be carried out exemplarily, so that methods and working techniques as well as research results that go beyond the local finding are introduced and discussed with regard to their correctness and importance.

Introduction

For over 150 years, glacier history and the reconstruction of the Ice Age glacier cover has been pursued with great success by glacio-geological and glacio-geomorphological methods. Thus, our knowledge of an at least three-times greater land-ice-cover of the earth during the Ice Age is only based on investigations of this kind. The essential characteristic of the methods is not the absolute dating — as it seems to be the strange opinion of several authors — but the position-specific arrangement of the sedimentological and geomorphological indicators with regard to the process of their glacial genesis. Only the three-dimensional arrangement of the positions of the individual key forms of a glaciation to each other provides evidence of a past glaciation. This true and classic method of the empirical paleo-glaciology is the criterion of this study on High Asia.

Flint wrote in his 4-page chapter on the Quaternary of Central- and Southeast-Asia: "... Nevertheless there remain many areas on which information is hardly more than conjectural ... Detailed studies of glacial stratigraphy have been few". (1971:672). In the meantime, the author has already carried out Quaternary-geological and glaciogeomorphological researches in Qinghai-Xizang (Tibet) and its marginal mountains for 34 years (Figure 1). Several of these expeditions led into remote, hardly visited areas. The investigations were done by means of those classical sedimentological and geomorphological methods in the field and laboratory with which the Ice-Age glaciations in other parts of the earth have also been reconstructed (Kuhle 1990b, 1991a). In High Asia the glacier reconstruction took place with the help of a whole system of glacial indicators forming a genetic network, which gives proof of the flow and shaping behaviour of glaciers and the necessary glacier climate. These detailed researches led to the synthesis of a Qinghai-Xizang (Tibetan) inland glaciation during the High Glacials (Riss and Wuerm; pre-LGP, LGP, LGM, MIS 5-2).

The Qinghai-Xizang (Tibet) Plateau is the Earth's largest high plateau with an area of more than 2 million km² and an average elevation of 4600 m. Owing to its subtropical latitude (27-39°N) extreme insolation values ranging from 800 to more than 1300 W/m² have been recorded in the summer months (Kuhle & Jacobsen 1988a). Heating of the plateau's debris surfaces causes about 80 % of this insolation and is converted into heat radiation, generating a pronounced low-pressure system over the plateau (Flohn 1981). The cooler and moister air masses of the summer monsoon drawn in from the Indian Ocean are deflected from east to west by the Himalayas and so do not reach the interior of the Qinghai-Xizang (Tibetan) Plateau. Hence, the Himalayas act as a climatic divide with convective precipitation of >6000 mm/a on their southern and <300 mm/a on their northern sides. Precipitation is low over the entire plateau: between 700 mm/a in the east to <50 mm/a in the west. Evaporation rates are high, ranging from 2500 mm/a in NW-Qinghai-Xizang (Tibet) (Van Campo & Gasse 1993) to 3200 mm/a in the Qaidam Basin (Chen Kezao & Bowler 1986), and the climate is semiarid to hyperarid, as the numerous saltwater lakes on the plateau bear out. This aridity was the decisive factor in assessing glacier size during the Last Glacial Maximum (LGM). Although in the first half of this century various authors reported evidence of significant local glaciers (Huntington 1906, Tafel 1914, Trinkler 1930, Norin 1932, DeTerra 1932, Odel 1925, see below), it was generally assumed that glaciation was not extensive, with maximum ice margins only a few kilometres away from the modern ones (v.Wissmann 1959, Shi et al. 1992, see below). In recent years, however, results have shown that the late Pleistocene climate was substantially more humid than today's, with large freshwater lakes in the Qaidam Basin (59,000 km²; Chen Kezao and Bowler 1986) and in the Tengger, Gobi (Pachur et al. 1995, Wuennemann et al. 1998) and Zunggar (Rhodes et al.,1996) deserts bordering Qinghai-Xizang (Tibet) in the north. At the same time, the argument that aridity is, in principle, a limiting factor for glaciation has proved to be obsolete. Spitsbergen with <300 mm/a precipitation and Ellesmere Island with <30 mm/a were long considered to have had little ice cover during the ice ages. However, it has since been shown that during the LGM, Spitsbergen was an integral part of the 2000 to 3000 m thick Barents Ice Sheet (Mangerud et al. 1998, Landvik et al. 1998) and Ellesmere Island was covered by the ≥1000 m thick Innuitian Ice Sheet (Denton & Hughes 1981, Dyke 1979, England 1999). Evidently, the decisive control of the extent of glaciation is not precipitation, but an increase in the area available for terrestrial glaciation owing to the lowering of the ELA (Equilibrium Line Altitude). The present mean ELA in Qinghai-Xizang (Tibet) is 5600 m asl, i.e., still in the steep relief of the peak region. Here, ELA variations of +/- 100 m induce differences in area of ~10,000 km². Below 5600 m asl, however, the plateau region begins, with exponential rates of area increase of 120,000 to 150,000 km² per 100 m of ELA-depression. Even an ELA anomaly of -300 m means that ~25 % of the total area of Qinghai-Xizang (Tibet) would be ice-covered, -600 m would mean an ice cover of about 55 % (today: 6 %) (Kuhle 1997a: Figure 41~48; 253~255; Kuhle et al. 1997a; 2001a, c; 2002a, c). Sensitivity experiments all show that the growth of an ice sheet covering the entire Qinghai-Xizang (Tibetan) Plateau is much more probable and starts earlier than in the high latitudes of the Laurentide and Fennoscandian ice sheets (Verbitsky & Oglesby 1992, Marsiat 1994).

1 The State of Research in Relation to the Author's Observations since 1973

A synopsis of older results and views on the Pleistocene glacier cover in High and Central Asia has been provided by v. Wissmann's compilation (Wissmann 1959, see also Bobek 1937). The glacier cover of Qinghai-Xizang (Tibet) is discussed in the recent Chinese literature by Shi & Wang (1979), and has also been reproduced by CLIMAP (Cline 1981). These authors speak of a 10 % to maximum 20 % ice cover of the mountains and plateaus of Qinghai-Xizang (Tibet). Even in the "Quaternary Glacial Distribution Map of Quinghai-Xizang (Qinghai-Xizang (Tibet)) Plateau" published in 1991 by the scientific advisor-, chief editor-, editor- and author group Shi Yafeng, Li Binyuan, Li Jijun, Cui Zhijiu, Zheng Benxing, Zhang Quingsong, Wang Fubao, Zhou Shangzhe, Shi Zuhui, Jiao Keqin, and Kang Jiancheng et al. (cf. Shi et al., 1992), this opinion is to a great extent repeated and supported. However, there was a first restriction: Zhou Shangze, a member of this group, agreed with the author's (Kuhle) reconstruction of an inland ice as for the Qinghai-Xizang (Tibetan) Plateau area on A'nyemaqen (cf. Figure 1 No.3) (Kuhle 1982a-d, 1982/83, 1984b, 1985a, b, 1986a, c, 1987a-e, 1988b). In this map he put down a plateau glacier area of 400 × 300 km in size. But time and time again, from as long ago as the turn of the 19th to 20th century, there were individual researchers, such as v. Loczy (1893), Oesterreich (1906), Handel-Mazzetti (1927), Dainelli & Martinelli (1928), Norin (1932), De Terra (1932) and others (cf. Kuhle 1988e: 416-417, 1988j), and they described ancient ice margin sites scattered throughout the high regions of Asia. According to the author's calculations, the above work represents ELA (equilibrium line altitude) depressions of more than 1000 m and indicates, locally, significantly more glacier cover than that the v. Wissmann scheme had acknowledged. However, the authors neither drew nor gave voice to such conclusions. Other early researchers, such as Huntington (1906), Tafel (1914), Odell (1925), Prinz (1927), Trinkler (1930) and Zabirov (1955a,b) (cf. Kuhle 1988e: 416-417), making more or less direct use of the data they obtained by observation, reconstructed larger glacier areas which, depending on the altitude of the mountains of plateaus, had built up only a few hundred metres of ELA-depression. The author has been fortunate in being able to carry out about 37 expeditions and research visits since 1973 (cf. Figure 1), some of which extended to seven months, with purpose of reconstructing the extent of glaciers in Asia during the glacial periods. The location and large number of areas under investigation permit reconstructions of the glacier areas to be made for the whole of

Qinghai-Xizang (Tibet) and parts of Central Asia. Reconstructions are supported by the data from some earlier authors (see above) and are in glaring contrast to the negligible ice cover published by CLIMAP as late as 1981 (Cline 1981) and the "Quaternary Glacial Distribution Map of Quinghai-Xizang (Qinghai-Xizang (Tibet)) Plateau" (Shi Yafeng et al., 1991). For example the extent of glaciation of High Asia during the Last Ice Age is given as approximately 2.4 million km², and is estimated to include a central thickness of about 2 km. Breaking up on the edges, ice discharged through the surrounding mountains as steep outlet glaciers (Figure 2) (Kuhle 1985b, 1986a, 1987a-c, 1988b, 1989a, 1993b, 1998a, 2001e, 2002b, 2004c, 2005c).

2 Previous Ways of Research with Data Collection and Methods of Argumentation in Detail

To reconstruct the Ice Age conditions, the search for past glacier margins by means of moraines and their topographic classification is necessary. In High Asia, this has been carried out by different researchers up to c. 1935. They mainly followed the caravan routes. It was especially Sven Hedin (1904-1907, 1909/1912, 1917/1922) who suggested a relatively insignificant glaciation of High Asia and Qinghai-Xizang (Tibet).

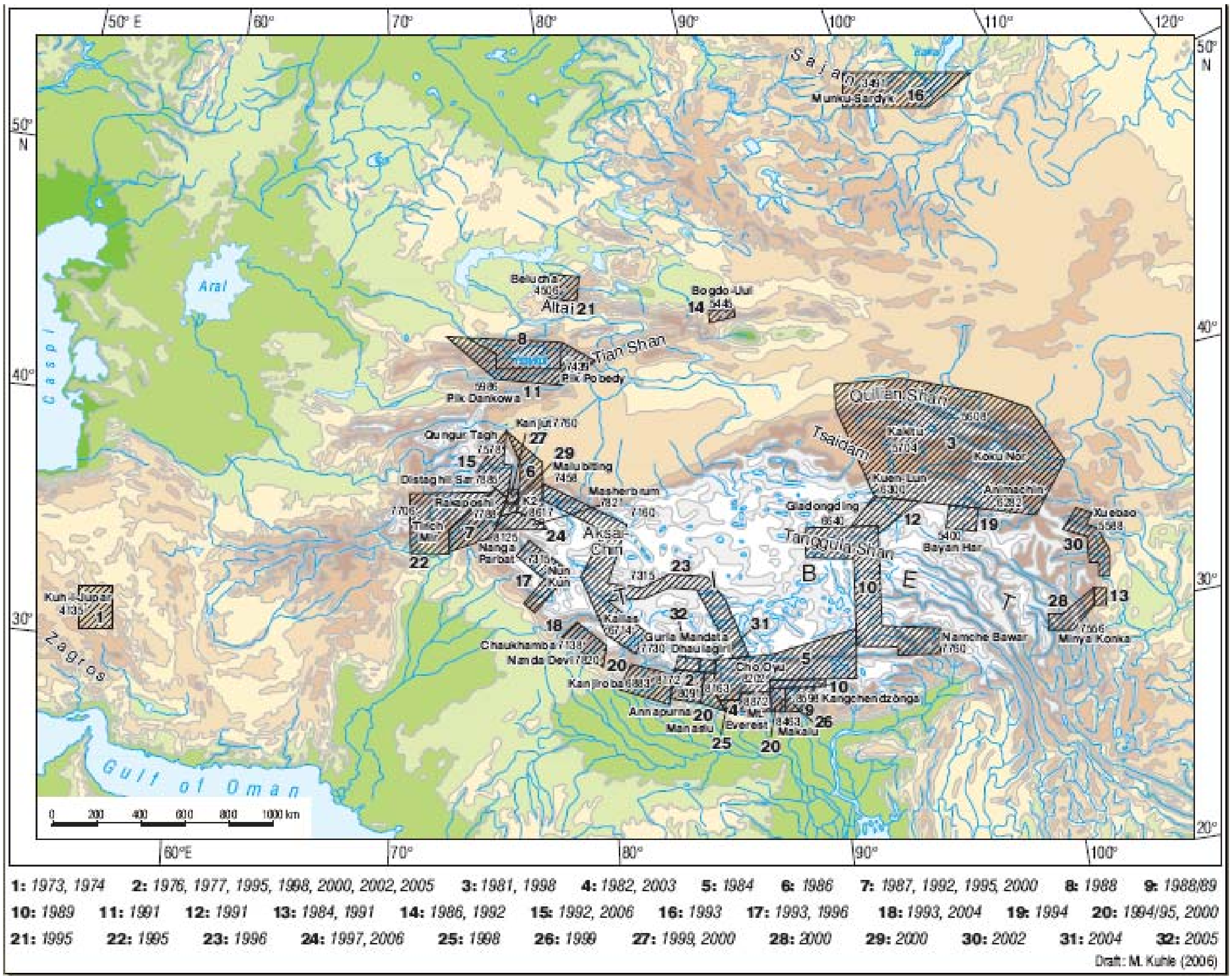

Figure1 The areas in Tibet, High- and Central Asia under investigation by the author since 1973

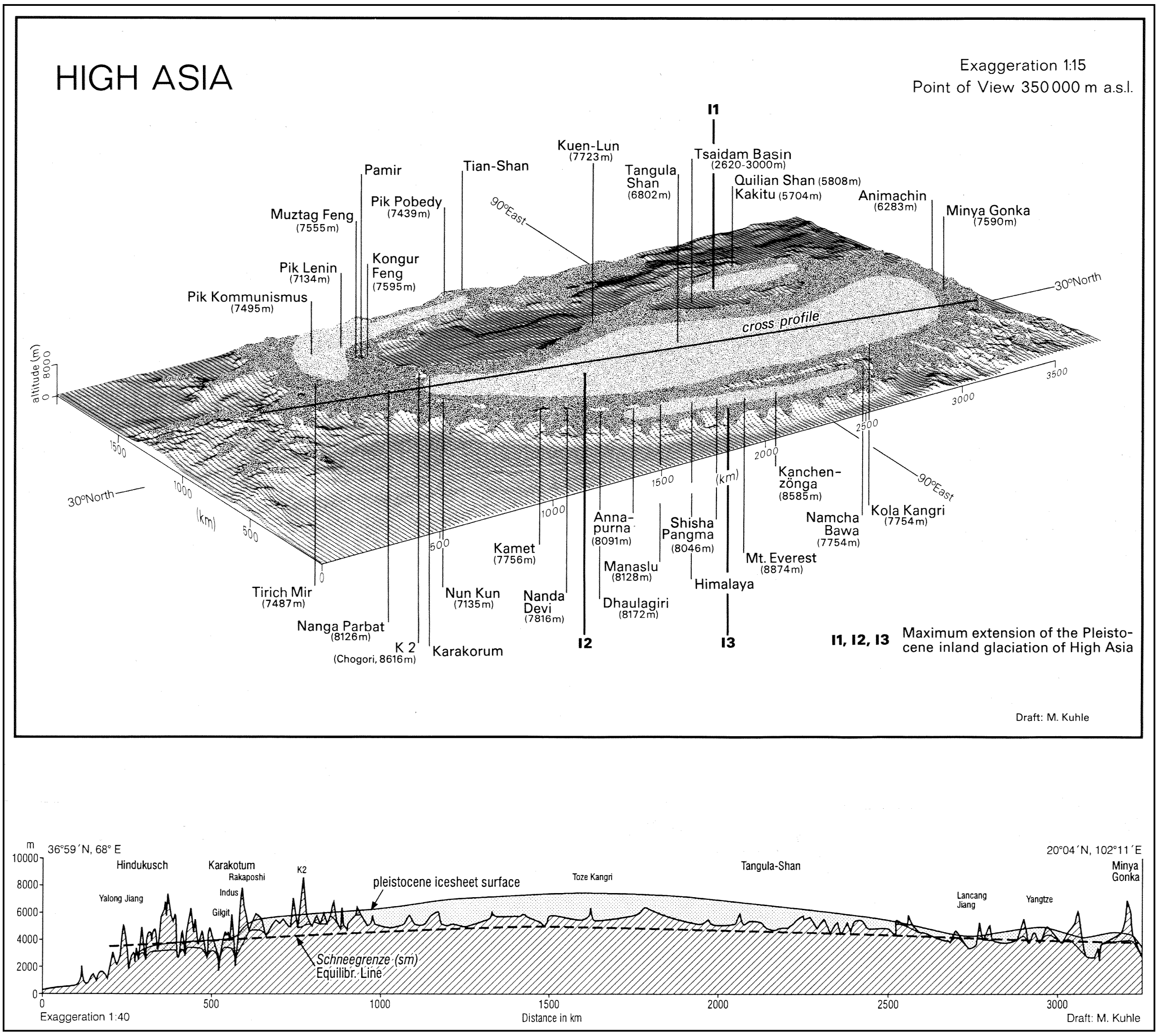

Figure2 (top) The reconstructed 2.4 million km² ice sheet or ice stream network, covering the Tibetan Plateau (Kuhle (1980-2006c), with the three centres I 1, I 2, I 3. Only peaks higher than 6000 m rise above the ice surface. (bottom) Cross profile of the central ice sheet from Hindu Kush in the west to Minya Gonka (Miya Gongga) in the east.

The same did Bobek (1937) with regard to the western foothills of High Asia — the Iranian Zagros Mountains. Due to political reasons, several areas could not be investigated until after 1950. In a great standard work v. Wissmann (1959) — who himself did not visit High Asia — has collected and written down all observations inclusive of the past snowline-depressions (ELA-depressions), the data of which he had calculated. Here, the glacial depression of the snowline, which approximately corresponds with the equilibrium line between the nourishing and ablation zone of a glacier, is used to measure the glacial cooling. With his compilation of literature v. Wissmann tried to show a harmonious comprehensive picture of the glaciation during the last glacial period. To avoid contradictions, he gave new meanings to some findings cited in the expedition literature that seemed to be out of place. This applies for instance to the observations of Weng & Lee (1946) with regard to the north slope of Quilian (Nan-) Shan on the northern margin of the Qinghai-Xizang (Tibetan) Plateau, to those of Odell (1925) with regard to its south margin, and also to the observations of Oestreich (1906) and Wiche (1958) as to the Deosai Plateau in the west and the Nanga

Parbat massif. Furthermore, the indications of Huntington (1906), Dainelli & Marinelli (1928) and Trinkler (1930) of a glaciation at different places in western High Asia have to be quoted in this connection. Zheng Benxing's (1999: 284) presentation of the results of Trinkler is wrong. Trinkler (1930) describes an Ice Age glaciation covering only one part of western Qinghai-Xizang (Tibet), but not a complete inland ice! V. Wissmann, who suggested that the interior of Qinghai-Xizang (Tibet) was not much strongly glaciated than today (v. Wissmann 1959:264), quoted a snowline depression of only 200-300 m for the West of High Asia and in excess of 1000 m for the outermost East (see below). Klute (1930), however, assumed in his map of snowline depressions — the only basis of which were studies of literature — a stronger glaciation of the currently arid West of High Asia during the Ice Age and a slighter glaciation of East-Qinghai-Xizang (Tibet) due to a weakening of the monsoon. In theory he calculated a global ELA-depression of 1400-400 m between 50°N and 45°S (Klute 1928). Up to the present, contradictions such as these can be found in the papers of those scientists who disagree with an inland glaciation of Qinghai-Xizang (Tibet) and an extended ice stream network in the surrounding mountains (Kuhle 1980-2006c). So, Frenzel (friendly personal information in Mainz, 1987) was of the opinion that an ice stream network glaciation in the currently arid Karakorum — first described by the author (Kuhle 1987a, f, 1988b-e) — might be true of the Last Ice Age, whilst at that time the currently monsoonal-humid east of the Qinghai-Xizang (Tibetan) Plateau ought to have been more arid and thus completely free of ice. In 2003, however, Frenzel retracted his opinion insofar as he explained (friendly personal information in Potsdam) that on the western margin of Qinghai-Xizang (Tibet), in the Karakorum, the findings he had presented on the meeting did not argue in favour of an Ice Age glaciation. In this connection, early publications of Frenzel (1959, 1960) are worth mentioning, who at that time — in the same way as Klute and v. Wissmann, i.e., without having visited the area concerned — suggested that Qinghai-Xizang (Tibet) was not glaciated during the glacial period. However, in the Atlas Mira (1964) the fringing mountain chains of Qinghai-Xizang (Tibet), in contrast to these authors, are presented to be strongly glaciated, though a reference to empirical findings in the field did not exist. Very similar, i.e., in a speculative manner, Central Qinghai-Xizang (Tibet) is depicted as ice-free during the Ice Age. In this respect the Atlas Mira (but without quotation) seems to have followed v. Wissmann's opinion. V. Wissmann's interpretation (see above) as to a snowline depression in West-Qinghai-Xizang (Tibet) of only 200 m (v. Wissmann 1959:1321) during glacial times and 200 to 300 m in the west-adjacent Kuenlun and East-Pamir, as well as to 1000 to more than 1150 m in the outermost east of the highland, inclusive of Minya Gonka (Gongga Shan) in Sichuan, was supported by the climatologist Flohn (1959, 1982). He explained this insignificant ELA-depression — in the European Alps, the Rocky Mountains and numerous other high mountains it was about 1000 to 1500 m — as dependent on the extraordinary aridity of those areas during glacial times. As for this, the traditional view of A.Penck and F.Machatschek (1913) from the beginning of the last century was pursued, postulating an insignificant Ice Age snowline depression in arid areas. During the following two and a half centuries Flohn's explanation has stabilized v.Wissmann's approach to such an extent that inconsistent moraine findings have been explained as wrongly diagnosed pseudo-moraines, i.e., accumulations originating from masses of mountain slides or — during more recent times — also from debris flows. Some authors have done this and still do it with the indication that the aridity of High Asia and Qinghai-Xizang (Tibet) is too important and therefore findings such as these are impossible. What has been neglected was that the observations which had already been selected were the basis of Flohn`s attempt of interpretation. This is not the first stabilizing circular reasoning of this type in science. However, apart from this, the cause of the scientific logical flaw is the abandonment of empirical, i.e., inductive research in the field in favour of a deductive, no longer empirical assertion that due to the aridity during the glacial period no glaciers could have existed in Qinghai-Xizang (Tibet).

1) It is not immediately possible to evidence the aridity of that time.

2) In the centre of the Arctic the annual

precipitation is only 37 mm (Schwerdtfeger 1970), i.e., it is highly arid. Nevertheless, the Antarctic inland ice has been built up and today shows a positive, i.e., well-adjusted mass balance explainable by the low temperature. This low temperature was also in Qinghai-Xizang (Tibet). Due to the still existing permafrost in Qinghai-Xizang (Tibet) (Kuhle 1997 : 243) and an even c. 10° colder high plateau during the Ice Age this is very plausible. In addition, in every single case, evidence had to be provided whether it was a pseudo-moraine or a real glaciogenetic accumulation. But this has never happened or at least was very seldom. The author only knows about the case of Heuberger, who due to a change of opinion like this, retracted at least part of his findings on the Ice Age glaciation of the south face of Cho Oyu (Central Himalaya) (Heuberger 1956). Heuberger, who in 1956 published a short study on a section of the research area, repeatedly retracted his findings and ice margin positions; so, e.g., on the "German Geographers' Day" in Göttingen, 1979. (Quotation: "Diese Moränen erfreuen sich inzwischen einer anderen Genese".). So, his opinion stated here cannot be considered as still valid. However, he had originally suggested (1956:356) an Ice Age ice margin position at c. 2500 m asl in the Dudh Koshi Nadi south of the Ghat settlement, providing evidence by erratics described c. 400 m above the talweg.

Back to v. Wissmann's interpretation of an insignificant glaciation of High Asia during the Ice Age:

To clear the last glacial period of contradictory moraine findings situated very low, his argumentation follows two different paths.

a) The indicators of the ice margin positions concerned are dated back into an older Ice Age (Mindel, Riss, middle Pleistocene?). Several authors have done this and still do it today, which means at a time when absolute datings are still lacking for the Last, pre-Last and pre-Last but one Ice Age in High Asia (see below Chapt.8). The only approximate datings are provided by radiometric 14C-dating. However, these are merely minimum ages of moraines reaching back at most 50 Ka (MIS 3-2), but not into the Riss Age (pre-LGP). Surface datings fulfil the necessary chronological frame, but due to rearrangements, weathering and exhumation they do not reveal the chronological connection as to the time when the moraine was deposited and thus to the age of the past glaciation.

b) Tectonic amounts of uplift are suggested to explain Ice Age moraines which — even in the sense of v. Wissmann — in some places are situated too high up. In fact they belong to the Late Glacial Stages after Kuhle.

With regard to a) v. Wissmann is in company of Dainelli (1922), De Terra & Paterson (1939) and others as, e.g., Han Tonglin (1991, 1999) who supposed several preserved moraine deposits to be older than the last glacial period. With that, the problem of explaining a corresponding snowline depression climatically (hygrically and thermally) has only been shifted into the pre-Last or pre-Last but one Ice Age, and the subsequent problems grow. So, v. Wissmann's conception is forced to explain why the difference of the altitude of the snowlines from the Riss- (pre-LGP) to the Wuermian Ice Age (LGP) was much more than 100-200 m, i.e., 500-600 m. 100-200 m also applies to many other areas on earth (Penck & Brueckner 1901-1909; Kuhle 1976). In addition, since the pre-Last Ice Age some 10 000 years more are available for tectonic uplifts (b), so that moraines, classified as belonging to a corresponding age, must have been deposited still lower than this would be the case for the Last Ice Age (LGP, Wuermian). This means, the further back the dating of the glaciation reaches, the lower the glacier margins are. Owing to this, the necessity occurs to explain a far greater climate change. The problem of backdating becomes especially striking with regard to the interpretation of Han Tonglin (1999), who at the time of the most important glaciation of Qinghai-Xizang (Tibet), i.e. — according to his opinion — during the "middle Early Pleistocene" is forced to suppose "a snowline about 2000 m asl" for Qinghai-Xizang (Tibet) (ibid.: 312), being 3000-4000 m lower than that of nowadays.

Last but not least, in the very steep relief of High Asia and the surrounding mountains of Qinghai-Xizang (Tibet) it is not very probable that clayey loose rocks like moraines remain on the spot for a rather long time, i.e., since the pre-Last or pre-Last but one Ice Age. In extremely high mountain areas with steep gradient curves, the reworking of the relief on valley flanks and valley floors, where the water is bundled, is very intensive and thus short-termed. V. Wissmann knew this, too. Nevertheless he suggested a cut of 400 m into the Mekong gorge since the Last Ice Age (LGP), that is within c. 20 000 years.

It has to be stated that the entanglement in increasing subsequent problems introduced here provides evidence of a fundamental methodical mistake in reasoning. To be reliable, the scientific method demands solutions of problems, but no creations of problems, i.e., simplifications and not complications to be sound. The primary question ought to be that one about its existence, i.e., in this case about the past existence of a reconstructed ice face and not about its age. This needs a reconstruction by means of position-specific glacier indicators (trough valleys, glacier striae, roches moutonnées, ground- and end moraines, etc.). A dependence on the chronological classification exists only insofar as the state of preservation of these indicators is concerned. The climate change necessary for the physical explanation of the glaciation is independent of the time during which it has been developed, i.e., it does not vary due to chronological distance. V.Wissmann, who followed the premises of Machatschek (see above) and other epigonal authors as Goudie *et al.* (1984), Derbyshire *et al.* (1984, 1988) and Shi Yafeng & Wang Jing-Tai (1979) noted no very extended past glaciation, but one that — on the basis of purely hypothetic age datings — was very limited during the Last Ice Age. As if it were not the maximum extent of the glaciers that had to be settled, these authors led a diplomatic rearguard action by placing the stress on "Last Ice Age" (LGP, Wuerm). But this is only a weak shifting of the goal in order to escape the question "were High Asia and Qinghai-Xizang (Tibet) heavily glaciated or not". Accordingly, the hierarchy of the questions is as follows:

1) How heavily glaciated were Qinghai-Xizang (Tibet) and High Asia in the past?

2) When was the maximum extent of the glaciers there?

So long as no reliable absolute datings are available (see Chapt.8), the maxime to use no additional assumptions has to be accepted as far as possible. This means that because — according to the previous research — the global ice ages had taken place simultaneously, the maximum Qinghai-Xizang (Tibetan) glaciation had also taken place simultaneously with the global coolings during the pre-LGP (Riss-Glacial) and lastly during the LGP (Wuerm-Glacial). There is no reason to suppose a breaking-off of an extended glaciation during the Last Ice Age (LGP), whilst a similar glaciation as this has existed during the pre-LGP, because the global-climatic difference of the ELA between the two ice ages was only 100 to 200 m. This applies the more, as there is no observation indicating a greater height of Qinghai-Xizang (Tibet) and High Asia during the pre-LGP than during the LGP. Rather the opposite is the case, i.e., c. 120 000 to 150 000 yrs ago, Qinghai-Xizang (Tibet) was according to the principle of actualism, which implies the current uplift, at least 600 m lower than during the LGP. Thus, the glaciation — if its extent was not nearly the same as during the pre-LGP — was probably greater during the LGP. This debilitates the assessment of v. Wissmann (1959), Dainelli (1922), De Terra & Paterson (1939) and others as, e.g., Han Tonglin (1991, 1999) as to an only minor glaciation during the Last Ice Age — however small or large it might have been — against a more extended glaciation of High Asia during the pre-LGP.

As an author, v. Wissmann (1959) is remarkable not only as an exponent of a minor ELA-depression during the Ice Age, but also because of the inner contradictions of his argumentations. So, he explains the insignificant snowline depression in the interior of Qinghai-Xizang (Tibet) by the lee position of these areas where it is not only dryness but also foehn. Accordingly, the luff side of the Himalaya as a guard against the rain must have been heavily glaciated. Because not only the lee position, but also the postulated foehn could have been especially effective, the Himalaya luff side must have even been very heavily glaciated. However, v. Wissmann denies this, too. He suggests — without observations in the field — an ELA-depression of merely 600-700 m during the LGP. In the meantime extensive findings obtained in the field in the course of several years yielded ELA-depressions of 1200-1500 m for the Himalaya S-side (Kuhle 1980, 1982e, 1983, 1987a, 1988g, 1990a, 1991b, 1997a, 1998a, 1999a, 2001b, 2002b, 2006b; Jacobsen 1990, Meiners 1999: 370/371, 2000:127, 132, König 1999, 2002, 2003, Wagner

2005, 2007, Zech *et al.* 2003).

3 The Maximum Ice Age Glaciation of High Asia after Kuhle 1974-2006 c

Especially with regard to several Qinghai-Xizang (Tibetan) areas of High Asia, authors like Cui Zhijiu (1964), Zheng Benxing & Shi Yafeng (1976), Shi Yafeng & Wang Jing-Tai (1979), and Zheng Benxing & Li Jijun (1981) are in accordance with v. Wissmann's (1959) opinion of a minimum glaciation (cf. also Zheng Benxing *et al.* 1998, inclusive of the literature cited there). However, these are rather short, general and summarizing articles with no field and laboratory findings. Thus, they cannot be understood in detail. Generally, observations of a very limited spread of ground moraines, as well as end moraines situated not far from the current glacier margins have been interpreted as indicators of a maximum past glacier extension. Kuhle, however (1976, 1980, 1982e, 1983, 1986b, 1987e, h, 1988a, 1990a, 1991b, 1994a, 1997a, 1998a,c, 1999a, 2001b, 2002b, 2006b), has classified these glacier indicators as being Late- and Neoglacial glacier advances in connection with a general postglacial retreat of ice of a High Glacial (last glacial period = LGP, MIS 3-2), much more extended glaciation with an ice stream network and, in central Qinghai-Xizang (Tibet), with dimensions of an inland ice of 2.4 million km^2.

Kuhle is in diametric contradiction with the interpretation of an insignificant Ice Age glaciation. First, this emerged with regard to the W-margin of High Qinghai-Xizang (Tibet), i.e., to the even just 4000 to 4200 m high E-Iranian Mountains. Here, the author (Kuhle 1974, 1976) strictly argued against the results of Bobek (1937) who for the Zagros Mountains in the NW indicated an LGP-snowline-depression of only c. 600 m, which was completely in the sense of Machatschek (1913) and later v. Wissmann (see above). Thus, Kuhle reconstructed an entirely different Ice Age climate. Also, the information of Frenzel (1960) about the course of the Ice Age snowline are in strong and fundamental contradiction with the findings in the field, because several hundred kilometres further to the N, Frenzel marked in his map a 440 m higher ELA of the last glacial period. Here, at 29-30° N, in the semiarid high mountains of Iran, the author gathered the following results in the field: Evidence has been found of two mountain glaciations in the 4000 m-high, currently non-glaciated Kuh-i-Jupar in the semiard Zagros: an older period during the pre-LGP (Riss-glaciation, c. 130 Ka) and a younger one during the LGP (Wuerm-glaciation, MIS 4 or 3-2: 60-18 Ka). During the pre-LGP glaciation, the glaciers reached a maximum of 17 km in length, and during the LGP-glaciation, they were 10-12 km long. They flowed down into the mountain foreland as far as 2160 m, i.e., 1900 m. The thickness of the valley glaciers reached 550 m, i.e., 350 m. During the pre-LGP, a 23 km-extended, continuous piedmont glacier lobe has been developed parallel to the mountain foot. During the LGP, the glacier termini mainly remained isolated in the mountain foreland. During the pre-LGP glaciation, the ELA ran at 2960 m and during the LGP-glaciation, at 3060 m asl, that is 1590, i.e., 1490 m below the current theoretical snowline. Thus, a temperature depression of c. 11-16°C, i.e., 10-15°C is proved for the SE-Iranian highland, c. 130, i.e., 60-18 Ka ago (Kuhle 1974; 1976). These results of a heavy mountain glaciation during the last glacial period have been confirmed by the research group of Hagedorn *et al.* (1974) as to the also arid Shir Kuh-massif located 300 km to the W.

Against this background it is not amazing that in the same geographical latitude but under more humid climate conditions and at much greater heights above sea-level of Qinghai-Xizang (Tibet) and its surrounding mountains, the author could demonstrate a nearly total glaciation of High Asia like an inland-ice or ice-stream network.

From 1976 to 1984 the author carried out expeditions and investigations in the field lasting altogether 19 months. They led to remote areas of the Himalaya and S- and N-Qinghai-Xizang (Tibet) nearly not investigated so far. His geomorphological, Quaternary-geological, i.e., sedimentological findings (Kuhle 1980, 1982a-e, 1982/1983, 1983, 1984a-d, 1985a, b, 1986a-f, 1987a-h) diametrically contradict the results of v. Wissmann and his epigones (see above).

After this first phase of research on which his approach of a total glaciation is based, up to date (2006), the author gathered further data from nearly all key areas of High Asia. During 37 campaigns of field investigations, all in all lasting many years (Figure 1), Qinghai-Xizang (Tibet)'s inland glaciation during the Ice Age and the ice stream networks of High- and Central Asia could be reconstructed on the basis of classic glacigenic forms of erosion and accumulation as well as on the accompanying sediments, that means on hundreds of petrographic- (sorting coefficient, C/N, lime content), grain-size- and morphoscopic analyses and the arrangement of the positions of these kinds of indicators. Absolute datings, obtained by different methods, classify this glaciation as being from the LGP (Kuhle 1988a-k, 1989a,b, 1990a-e, 1991a-c, 1993a,b, 1994a-c, 1995a-c, 1996a-c, 1997a-d, 1998a-h, 1999a-e, 2000a-f, 2001a-e, 2002b-f, 2003a,b, 2004a-f, 2005a-c, 2006a-c, Kuhle et al. 1989b, Kuhle et al.1994, Grosswald & Kuhle 1994, Grosswald, Kuhle & Fastook 1994, Kuhle *et al.* 1997a,b, Kuhle *et al.* 1998a,b, Kuhle *et al.* 1999, Kuhle *et al.* 2000). The most important indicators of the past glacier cover of High Asia are the following: Data of the lowest past glacier margins are provided by the lowest ground- and end moraines (e.g., Kuhle 1982d: 68pp., Kuhle 1993a: 135). Hard indicators in the mountains surrounding Qinghai-Xizang (Tibet) are glacigenic valley- and slope forms with glacier abrasions, -smoothings, i.e., -polishings and -striations (e.g., Kuhle 1994a: 153 pp.) and findings of erratics situated at high slope positions and on high valley divides (e.g., Kuhle 1989a: 265). On the Quinghai-Xizang (Tibet) Plateau, the E-Pamir Plateau and the Tienshan Plateau the ice cover has been evidenced by forms of roches moutonnées and ground moraine covers (e.g., Kuhle 1993a: 139 pp.). According to polish lines, here too, minimum ice thicknesses have been recorded; the most important ice thickness was estimated at c. 2700 m (Kuhle 1989a: 265). By means of glacigenically rounded mountains (glacially streamlined hills) and polish lines, ice levels could be reconstructed on the highest summits of the Tanggula Shan in Central Qinghai-Xizang (Tibet), situated here at least 1000 m above the height of the plateau (Kuhle 1991b: 133 pp, 145, Photo 2). Further to the S, in the lower plateau and basin areas, ground moraines with block-sized drift and roches moutonnées have been found as far as down to 4500 m asl (Kuhle 1991b: 151 pp., Photos 12-20). From these findings an exhaustive inland ice has been reconstructed in the region between the Kunlun and Tanggula Shan (Figure 1 No.10 and 12). On mountain ridges and summits in the area of the Kunlun Pass (La or Shankou) decametre-thick moraine material and erratic granite boulders on bedrock schist have been documented (Kuhle 1993a: 140, Figure 12; 1995a). At this place this provides evidence of a thickness of the outlet glacier of over 600-700 m. Further detailed findings as to the middle Kunlun can be found in Kuhle 1987e (266 pp.). In the meantime they are confirmed by Hebenstreit (1999).

From the very extended field and laboratory findings covering Qinghai-Xizang (Tibet) on a large scale, only a few key localities have been chosen to be mentioned here. They will be completed by an example from the most arid, lowest situated area of Central-W-Qinghai-Xizang (Tibet) which is thus most hostile towards glaciation (Kuhle 1999a). It is the area of the Nako Tso, a lake, the level of which is situated in a large depression of the ground at only 4220 (4218) m asl and thus in a basin in a topographically lowest position of the whole of Central-Qinghai-Xizang (Tibet) (Figure 2 between Nun Kun and Kamet; Photo 1). This lake is far away from every currently glaciated mountain group. Its shore-line undercuts the slopes of the surrounding hill chains that fringe the basin of the lake, so that fresh cliffs with wave-cut notches have developed. This documents that the Nako Tso is a young lake, filled into another relief than a limnically developed one, i.e., it has been filled in later. The undercut slope profiles are covers of ground, i.e., ablation moraines preserved in many places (Photo 1 and 2). Even glacially streamlined hills and perfectly preserved, very young roches moutonnées have been found just as frequently. Their slopes have been limnically undercut (Photo 1). Thus, it is proved that the Nako Tso, in spite of its driest and topographically lowest position, occupies a flat upland area which during the Last Ice Age (LGP to Late Glacial) must have been covered with the inland ice (Photo 1). In widely scattered positions, erratic granite boulders have been found, which confirm this observation. Some of the examples are depicted in Photo 1 and 2. These are erratic boulders in size from metres up to that of a hut, situated at the eastern end of the lake, i.e., positioned towards the centre of Qinghai-Xizang (Tibet). They either lie on ground — or ablation moraines covering the relief or they are — and here mainly the smaller granite boulders are concerned — integrated into the moraine, i.e., embedded into its fine material matrix. The ground moraine and the light erratic granite boulders overlie the outcropping dark metamorphic sedimentary rocks (Photo 2). Erratic granite boulders such as these have been found nearly up to the culmination of hill- and mountain ridges. But also at places where they have been deposited on the lower slopes, bedrock granites are lacking on the upper slopes (Photo 2), so that a pure down-slope transport of the boulders can be ruled out. Thus, the long-distance transport by glacier ice is unambiguously evidenced. At a distance of c. 50 km, in a valley S of the Rutog settlement, the author has mapped the occurrence of granite bedrock as a possible area of origin (33°11′N/79°50′E). However, this valley does not lead down from a high catchment area (high mountain group) to the Nako Tso basin. Its catchment area with its heights and expansions rather corresponds with the rest of the catchment areas surrounding the Nako Tso basin, which with regard to their hill- and mountain topography are very similar to each other and therefore correspond as glacial catchment areas. From this one can draw the conclusion that at a same and on a large scale simultaneous ELA-depression of c. 1300 m during the LGP up to about 1000 m during the Late Glacial, the supply of glacier ice from all surrounding areas into the Nako Tso basin must have been equally rich and intensive. This, however, makes probable that a glacigenic transport of erratic granite boulders could have taken place, too, from other valleys where bedrock granite did occur. At the same time, these considerations illustrate the complete ice cover of this area proved by the erratic boulders. For the area concerned, a snowline-depression of c. 4400 m asl, i.e., 200 m above the lake level of the Nako Tso and — according to the additional depth of the lake — a little more above the bottom of the Nako Tso Basin, has been reconstructed (Kuhle 1999a, Figure 34). This was one of the few basin and valley bottom areas of Qinghai-Xizang (Tibet) situated below the High Glacial climatic snowline!

The Late Glacial to postglacial age of these W-Qinghai-Xizang (Tibetan) lakes has already been documented by the limnological study of Van Campo & Gasse (1993) and thus tallies with the results of a High (LGM, LGP)- to early Late Glacial inland ice cover of the relief and the following Late Glacial to Holocene lake development on the Qinghai-Xizang (Tibetan) plateau suggested by the author (see, e.g., Kuhle 1999a: 45-47).

Summarizing this section, it can be stated that the glacial-geological and glacio-geomorphological findings, i.e., trough valleys with a U-shaped cross-profile, glacigenically rounded and sharpened mountain forms (roches moutonnées and glacial horns), rock abrasions with polish lines and glacier striae as well as moraines without and with erratics far away from a current glaciation, in all investigation areas in the centre of Qinghai-Xizang (Tibet) and also along its margins (Figure 1) argue in favour of a completely covering inland- and icestream network glaciation (Figure 2). As shown in Figure 2 (bottom), the ELA (equilibrium line altitude), reconstructed with the help of end moraines of the marginal outlet glaciers, has run on a large scale (83-86 %) below the level of the relief surface of High Asia (of Qinghai-Xizang (Tibet) and the surrounding mountains). This applied to an equilibrium line depression of 1000-1300 m against nowadays. Due to the self-heightening of the areas of glacier feeding by increasing ice accumulation this effect has been strengthened. Thus, from the uplift of Qinghai-Xizang (Tibet) above the snowline (ELA) a c. 2.4 million km² extended and 700-2700 m (mean value about 1000 m) thick inland ice and ice stream network has resulted (Kuhle 1998a etc.).

In 1991, part of the findings in the field has been introduced during the INQUA EXCURSION 14 A (Kuhle 1991d, Kuhle & Xu Daoming 1999) and discussed with Zheng Benxing & Jiao Keqin (1999) in an open session. This debate has been taken down and published by Osmaston (1999).

Six years after the author's first publications on the reconstruction of the Qinghai-Xizang (Tibetan) inland ice, the Brockhaus-Encyclopedia in its edition of 1988 (Vol.6: 240 map: Maximalvergletscherung der letzten Eiszeit) printed Kuhle's (1985b) map of the inland ice reconstruction. After eight years Liedtke (1990) followed this new interpretation of a very extended High Asian glaciation by taking over Kuhle's map of the inland ice reconstruction (Kuhle 1985b, 1986a) into his LGP-glaciation map. Gellert (1991) is also convinced. The LGP-world map of the Glaciological Atlas of the Russian Academy of

Photo 1 At ca. 4220 m (aneroid measurement: 4120 m asl at high pressure; lake level according to ONC 1:1 000 000 G-7: 4218 m), from the easternmost end of the Nako Tso (lake) (33°31′ N/79°55′ E; Figure 2 (top) I2 between Nun Kun and Kamet) facing W. During the Ice Age (LGP) the basin of the present-day Nako Tso has been completely filled by glacier ice up to a minimum height of the inland ice surface (—o—) at over 5000 m asl — probably even up to ca. 6000 m asl (cf. Photo 2). This is to be evidenced by the round-polished mountains and roches moutonnées (◓) as well as by their ground and ablation moraine overlays (■) preserved in places. (↗) marks an erratic granite boulder, lying in its formation of ground moraine cover on calcareous sedimentary rocks of the roche moutonnee (◓ white on the left). Since deglaciation, the down-flowing precipitation water has cut fresh funnels into the ground moraine material (■), which has been newly deposited in the form of fans at the slope foot (□ on the left). Limnic undercutting has caused the steepening of the lower slope (■ below). (□ in the foreground) is moraine material, reworked by the lake along its shore line and thus also heavily frost-weathered. The roche moutonnee from limestone in the centre of the photo forms a small island in the lake (◓ white on the right). With its Holocene to current shore line the lake has undercut the soft slopes of this glacially rounded hill (⇧). This confirms that the Ice Age glacigenic morphological regime has been relieved by a postglacial limnic one and the lake is of postglacial age. Photo M. Kuhle.

Photo 2 5 km N from the locality of Photo 1, again at the E-end of the lake Nako Tso located towards Central Tibet, several hundred meters away from its current shoreline, this large erratic granite boulder (○) has been deposited by the inland ice. Locality: 4225 m asl.; 33°33′N/79°57′E; Figure 2 (top) I2 between Nun Kun and Kamet. Direction: facing E (left margin) up to S (right margin). Here we are in the lowest (Figure 32: Na-K'ot Ts'o) and most arid area of Central W-Tibet. (↗↙) mark further depositions of erratic boulders on the highest slope sections of the ridge, completely overthrust by the ice (◓ left). They are incorporated into a ground moraine cover (■), lying on metamorphic bedrock (▼), from which the local glacially streamlined mountain ridges (◓) are built up. Late Glacial and postglacial slope rills, funnels and grooves (▼) have been cut into the bedrock. (△) are small flat fans consisting of ground and ablation moraine removed after deglaciation. (—o—) mark the Ice Age (LGP) minimum surface height of the ice completely covering the relief, which probably ran at ca. 6000 m asl. (o— on the right) (cf. Photo 1). Photo M. Kuhle.

Science (1999) publishes the updated presentation of the inland ice of Kuhle (1998a Figure 8,13). Also, Xu Daoming & Shen Yongping (1995) as well as Han Tonglin (1991, 1999) follow Kuhle's opinion as to a complete glaciation of Qinghai-Xizang (Tibet). The last-named, however, expects that this happened during a "middle Early Pleistocene" ice age (ibid.) and not during the last glacial period, i.e., the LGP. However, this chronological classification is based on methodologically uncertain methods of dating (see Chapt 8). For the Kunlun N-slope on the S-margin of the Tsaidam-depression (Figure 1 No.3; Figure 2 top) Drozdowski (1992: 39-40) reconstructs a Golmud-valley-glacier of the LGP about 45-50 m in length, which can also be interpreted as an outlet glacier as defined by Kuhle (1982d, 1985b, 1987a,c, 1988b,g,i, 1989a, 1993a, 1995a).

A further author who agrees with Kuhle's interpretation (1997a, 1998c) — this time with regard to the likewise arid E-Pamir on the NW-margin of High Asia (Figure1 No.15; Figure 2 top) — is Schroeder-Lanz (1986). He also diagnosed lateral- and ground moraines in the Gez-valley, in the valley chamber between 2400 and 2180 m asl (Schroeder-Lanz 1986: Figure 4 and 5, Kuhle 1997a Figure 14 No.3-12) and describes the LGP Gez- glacier to be at least in part a NW-outlet glacier flowing down from Muztagata (Muztag Feng) and from the W- and S-side of Kongurshan (Kongur) as well as from the completely glaciated high valley of the E-Pamir plateau (cf. Kuhle 1997a: Figure 14 No.19-11) reaching down to the Tarim basin. According to Kuhle's (ibid. Photo 14-37, Figure14 above No.11) reconstruction, the Gez-glacier flowed down to c. 1800 m asl (38°50′N/75°31′E). In these terms Schroeder-Lanz writes (1986:40. "At a High Glacial snowline depression of 1200, i.e., 1600 m according to Kuhle (1982a,c,d,e, 1983, 1984b,c, 1985b, 1987e) these glacier tongues of Muztagata and on the W- and S-face of Kongurshan must have filled the high valley" (Schroeder-Lanz 1986 Figure 2). As to the N-margin of High Asia, the E-Tienshan, more exactly the Bogdo Ul (Bogda Shan) (Figure 1 No.14), in the N-sloping Sky Lake valley, Schroeder-Lanz reconstructs a snowline depression of 1200 m for the LGP, too (1986,Figure 8). The author (Kuhle 1998a: 97) comes to the same value for the LGP and to an ELA-depression of 1400 m for the pre-LGP glaciation in this valley (MIS 6-5?). In the Daxi Gou valley (Urumqi-River valley, 43°50′N/88°20′E) a c. 50 km long valley glacier reached down to the valley exit. The end moraines of the LGP are situated at c. 1900 m asl, so that here, too, an ELA-depression of 1250 m is proved (ibid.: 97).

In addition, Zech et al. (1996) substantiated with their agrogeographical observations as to the Pleistocene and Holocene glaciation of the western Tienshan (Uzbekistan) ELA-depressions of c. 800 m in spite of a relatively high aridity. At least part of these findings supports the results of the author (Grosswald & Kuhle 1994, Kuhle et al. 1997b, Kuhle & Schroeder 2000). However, Kuhle et al. do not consider the glacier stages introduced there to be the lowest ice marginal positions of the LGP, but of the Late Glacial. The reason for this is: the oldest lateral moraines described by Zech et al. are situated near to the valley floors of trough valleys. Accordingly, the areas of trough valley flanks towering above, have to be classified as belonging genetically to a higher, older glacier level. This thicker glacier must have had a clearly greater ELA-depression and fits into the picture of an ELA-depression of 1200 m (ibid.) reconstructed by the author.

Here, the results of v. Klebelsberg (1922) and v. Ficker (1925 and 1933) from the Transalai-Mountains in western High Asia (W-adjacent to the Tienshan) have to be acknowledged. Due to their expeditive field investigations, these scientists could provide evidence of ELA-depressions of 1000 to 1500 m. Zabirov (1955 a,b) who concedes at most 800 m in this arid region, might have rather placed the Late Glacial glacier stages (Stage II-III after Kuhle 1982e) into the maximum stage of the LGP. Porter (1970), however, who originally also found out a snowline-depression of c. 1000 m for Swaat Kohistan during the LGP, told the author about his doubts as to his own results and referred to the rather inexact maps of this area (friendly personal information, August 2003, INQUA, Reno).

For the Himalaya, in the Manaslu massif, which is E-adjacent to the Annapurna group, Jacobsen (1990:70) confirms the investigations of the author from the Dhaulagiri- and Annapurna Himalaya (Kuhle 1982e, 1983). Due to his glacio-geomorphological researches he is able to show that in the main valleys, also in the lower Marsyandi Khola, the Wuermian (LGP) glaciers moved down to nearly 1000 m asl. According to younger field- and laboratory analyses of the author, the Buri Gandaki glacier reached down to 680 m and the Marsyandi glacier even to 460 m as far as to the current position of the Dumre settlement (Kuhle 1997a, 1998a). Jacobsen (1990) also comes to an ELA-depression of over 1200 m.

In the Macha Khola, an orographic right side valley of the Buri Gandaki in the S-slope of the Manaslu Himal, Zech et al. (2003) proved an ELA-depression of 1300 m and — with the help of 14C-dating — classified it as belonging to the LGP. Further confirming classifications are Ghasa Stage (I) and Sirkung Stage (IV) after Kuhle (1982e, 1983, 1998a: 82 Table 1) with 12.9 +/- 1.4 to 13.7 +/- 1.8 Ka BP. They are actually classified as being from the Late Glacial and confirmed with an ELA-depression of 1125 m, i.e., 650 m (Zech et al. 2003: 2259,2261).

In the upper Marsyandi Khola, particularly in the Annapurna-N-slope, Zech et al. (2001) confirm an arrangement of the Late Glacial glacier stages after Kuhle (1982e, 1983) specifying them on the Annapurna III-N-glacier. The results of pedological tests and detailed ELA-calculations of Wagner (2005, 2007) corroborate the glaciogeomorphological findings of the author from the upper up to the lower Thak Khola between Annapurna- and Dhaulagiri-Himalaya (Kuhle 1982e, 1983, 2006a) inclusive of the sequence of stages from the LGP through the Late Glacial up to the Neoglacial as well as the corresponding ELA-depressions of over 1200 m on average.

Due to very detailed field investigations, sediment analyses and ELA-calculations Meiners (1996, 1997, 1998, 2001) found in the semi-arid mountain-groups of the Tien Shan and NW-Karakorum as well as in the monsoon-humid Rolwaling- and Kangchenjunga Himalaya (Meiners 1999, 2000) a nearly corresponding number of 4 to 6 Late Glacial, 3 Neoglacial and c. 5 Historical glacier stages. The ELA-depressions of the younger Late Glacial stages are 500-850 m (Meiners 1996: 76, 118, 128, 131, 171; 2001: 434); those of the older Late Glacial stages are already 900-1350 m (Meiners 1996: 107; 1998: 62; 1999: 370/371; 2000: 127, 132). This corresponds to the results of the author who reconstructed 1100 m for the Late Glacial Stage I and 1000 m for Stage II in the mountains surrounding Qinghai-Xizang (Tibet) (Kuhle 1982e, 1983, 1986b, 1987a,e, 1988g, 1989a, 1990a, 1993b, 1998a). König (1999, 2003, 2004) largely confirms the glacial (LGP) extensions of the Rolwaling- and the Tamur glacier in the Himalaya-S-slope, as they have been published by Kuhle (1990, 1999). A minor difference is that König (2003, 2004:282) reconstructed the Tamur glacier 6 km further down-valley and c. 100 m lower down than Kuhle (1990a), i.e., up to 650-680 m asl. This means a 50 m lower ELA. König (2003, 2004: 280) reconstructs the end of the Rolwaling glacier at the position of the Singali Bazar settlement at 950 m asl; Kuhle (2001:391) at c. 860 m, down-valley from the Marbu settlement. This is also a merely insignificant difference of the glacier length with a difference of the ELA of only just 50 m. A far-reaching correspondence does exist, too, with regard to the Late Glacial (Late LGP) glacier history in the Khumbu Himalaya. The study of König (2001:452 Figure1) on the Late Glacial glaciation of the lower Bote Koshi Nadi and its four tributary valleys provides considerations as to the relativity of Late Glacial ELA-depressions and the extension of glaciers. In the context of Kuhle's researches (1986b, 1987a,h, 1988b, 2006b: 210-213 Chapt. 3.8.3-6) it has to be stressed that the Late Glacial ELA-depression of 900 m compared with the current snowline, established by König (2001: 453/454), due to the findings introduced in this section of the valley area has also been calculated and thus confirmed by the author for the late Late Glacial, the Sirkung-(IV) and the Dhampu Stage (III) (Kuhle 2006b: 97 Table 1).

In High Asia, Iturrizaga (1999a,b) showed with great glaciogeomorphological accuracy that debris cones and fans for the most part consist of kames and High- to Late Glacial (LGP) ground moraine material that has been displaced down-slope. This concerns decametre-thick ground moraines very high up, in part situated 1000 m above the valley bottoms of the Karakorum and Himalaya. Currently, they are linearly cut and moved by solifluction, as well as secondarily dislocated by debris flows and slides. In many places, very thick Ice Age ground moraine pedestals and ramps are cut by slope ravines and thus remoulded into cone-shaped residual debris bodies (Iturrizaga 1999a: 84 among others). In addition, Iturrizaga

(2001, 2006) demonstrates that the lateroglacial valleys and landforms in the Karakorum mountains are transglacial landforms. The very big moraine fringes of the current, rather narrow postglacial and interglacial glaciers have merely been formed - just as the debris cones - by the rearrangement of Ice Age ground moraines (ibid. 2006:98, 102), which during the relief-filling, up to over 2000 m-thick LGP-valley glaciations and the develop- ment of outlet glaciers of the Qinghai-Xizang (Tibetan) ice have come into being. These findings (Iturrizaga 1999a: 124/125, 247 and others) also confirm the glaciation reconstructions of the author in High Asia (Kuhle 1974-2006c).

Whilst these publications corroborate Kuhle's opinions, there are other researchers who do not agree with them— not even in the early nineties. They come to other or contrary conclusions which, however, differ widely from each other. So, a glacier extension of only 297 000 km² and a snowline depression of merely 500 or even just 300 m on average is inferred from the height of cirque floors or the position of end moraines on the Qinghai-Xizang (Tibetan) plateau by Derbyshire et al. (1991) in a summary of investigations of Chinese authors. With that the old conception of v. Wissmann (1959) is followed again. To be consistent, diamictic deposits outside of the glacier areas are indicated as being "debris flood deposits" or "debris flow deposits". Shi et al. (1992) show a selection of the same findings. Even in the "Quaternary Glacial Distribution Map of the Qinghai-Xizang (Tibet) Plateau" published in 1991 by the authors-group Shi Yafeng, Li Binyuan, Li Jijun, Cui Zhijiu, Zheng Benxing, Zhang Quingsong, Wang Fubao, Zhou Shangzhe, Shi Zuhui, Jiao Keqin, and Kang Jiancheng (cf. Shi et al. 1992) this opinion is repeated and supported to a great extent. However, there was a first restriction: Zhou Shangzhe, a member of this group, agreed with the author's (Kuhle's) reconstruction of an inland ice as for the Qinghai-Xizang (Tibetan) plateau area on Animachin (A'nyemaqen) (cf. Figure 1 No.3; Figure 2 top) (see Kuhle 1982a,d, 1987a-e, 1988b). In this map he put down a plateau glacier area of still 400 × 300 km in size.

Similar to these authors, Hövermann et al. (1986, 1993) and Hövermann & Hövermann (1991) investigated past glaciations in the marginal mountains or in Qinghai-Xizang (Tibetan) mountain massifs. They also argued against the inland ice in High Asia reconstructed by the author (Kuhle).

Zheng Benxing (1999: 284) once more summarizes the traditional interpretation he had already formulated in 1988: "The main divergence of the two different views lies in the different understanding of the sediments, sedimentary sequences and landforms on the plateau. Large amount of recent sediments and geomorphological studies show that most of the deposits regarded as moraines, which were used to reconstruct very low paleo-snowlines and extensive ice sheets are actually debris flow and slope wash-related deposits." With regard to this, the author (Kuhle) remarks: Naturally, a glaciofluvial remoulding has happened in correspondence with the Late Glacial thawing of the inland ice, as well as a subaerial remoulding since the complete deglaciation during the Holocene. Accordingly, a glaciofluvial and fluvial covering of the ground moraines preserved on a large scale on the Qinghai-Xizang (Tibetan) plateau, and an insignificant reshaping and destruction of glacigenic forms of erosion, which can also be met on the entire Qinghai-Xizang (Tibetan) plateau and in its marginal mountains, must have taken place. This is the case in all Ice Age glacier areas on earth. Debris flows are especially frequent in moraine areas, because moraines are huge masses of loose material, the clayey matrix of which favours the flowing process. Accordingly, numerous debris flows can even be an indirect indication of a past glaciation.

Further exemplary mistakes occur in the paper of Burbank et al. (1991) "Relative Dating of Quaternary Moraines, Rongbuk Valley, Mount Everest, Qinghai-Xizang (Tibet. Implications for an Ice Sheet on the Qinghai-Xizang (Tibetan) Plateau". 1. The weathering datings of the authors ignore the hydrothermal decay in the outcropping source rock, though an appropriate study of Heydemann & Kuhle (1988) on the Mt. Everest N-slope is in hand (see Chapt.8). 2. In their very small research area of 8 km in length, the authors, in spite of the fact that they have determined only relative degrees of weathering, classify the lowest past ice margin position — without any absolute indication of dating — as being from Stage 6 (Middle Pleistocene) (ibid.: 3,16). They do not consider the great number (5-7) of lower end moraines and ice marginal positions mapped by the author (Kuhle) in the adjacent areas. Due to his chronology of ice margin positions Kuhle classified the position in the Rongbuk valley as belonging to the oldest Neoglacial Stage (Nauri Stage V, c. 5500 YBP, Middle Holocene) (Kuhle 1982e, 1983, 1986b, 1987a,h, 1988a,g, 2006b). Burbank et al. reject this classification of the author (that has been taken incompletely from a minor publication; the main publication on the Rongbuk valley is Kuhle 1988a) with the pseudo-argument and assertion that according to his (Burbank's) relative chronology, the ice marginal position concerned must be the lowest past glacier stage. Thus, in an inadmissible manner, a relative chronology has been interpreted as an absolute dating and classified as absolute age dating "Stage 6" (Middle Pleistocene) (ibid.:3,16). With this circular reasoning, i.e., on the basis of relative dating — now declared as absolute — a past glaciation of much greater dimensions with an ELA-depression of over 1000 m (Kuhle 1980, 1982e, 1983, 1986b, 1987a,h, 1988a,g and others) which among other things has been proved by freshly preserved glacier striae far above the valley bottoms at 2095 and 1800 m asl (Kuhle 1982e: Photo 126, 95, 96) seemed to be excluded. However, the corresponding ELA-depression of the Rongbuk glacier stage discussed in Burbank et al. was only 100-150 m (Burbank et al. are wrong in speaking about c. 400 m (ibid.16). This is impossible, because the ice margin concerned is situated only 200 m lower than the current glacier terminus: 200: 2 = 100, but not 400). A depression of 100m up to at most 150 m as a maximum snowline depression of the Pleistocene from Stage 6 (Middle Pleistocene; ibid. 3 Figure 2B) up to present-day — as postulated by those authors — would be a singularity on earth and does not have a climate-physical basis. At the same time only two further glacier stages have been mapped at a horizontal distance of only 8 km from the current ice margin position up to that of the supposed Stage 6, classified as belonging to the Late Pleistocene (MIS 3-2?) and the Holocene Neoglacial. According to the author's investigations (Kuhle 1980-2006c) in many areas of High Asia (Figure1), as a rule seven to eight glacier stages (three in the Neoglacial and five in historical times up to c. 1950) are situated only between the Neoglacial and the current glacier margin (Kuhle 2006b etc.). Zheng Benxing (1988, Figure3) gets somewhat closer to the truth than Burbank et al. (1991). Analogous to his assumed Late Pleistocene ice margin position he comes 4 km further down-valley than Burbank et al. with their Middle Pleistocene ice margin position. Accordingly, Zheng Benxing does not agree with Burbank et al. despite their indications in this direction. So there exist two different interpretations. The only agreement is that both of them consider Kuhle's opinion to be wrong. There is not much left than to make a remark about the seemingly plausible opinion that in the arid precipitation shadow of the Himalaya and Karakorum no large-scale Ice Age glaciation occurred. Already in 1987, however, this has been unambiguously disproved by fresh glacier polishings and -striae reaching down up to a height of the valley bottom of c. 3400 m in the Surukwat valley N of the Mustagh Karakorum and Aghil mountains (Kuhle 1988c: Picture 4 and 5, 1994a: Figs. 93,128,138 No.46 and 33). Here it is not only extremely arid with an annual precipitation below 100 mm, but the clear glacier polishings are situated c. 1500 m below the level of the Qinghai-Xizang (Tibetan) plateau. This ought to be seen as a further indication of the Qinghai-Xizang (Tibetan) inland ice.

Similarly striking contradictions and discrepancies have been published by Fort (2000 Figure3) — even with opposite results. Here, a lowest LGP ice margin position (LGM c. MIS 3-2?) at 2800 to 3000 m asl has been described for the Miristi Khola on the SW-side of Annapurna (Central Himalaya). This corresponds to an ELA-depression of only 600 m for the monsoonal-humid weather side of the Himalaya. On the semiarid N-side, in the precipitation shadow of the over 8000 m high Annapurna massif however, the Late Glacial ice margin of Kuhle (1982e) is confirmed near to the Kingar settlement, although by mistake it has been put into the LGP. Despite the aridity in the Muktinath basin, the ELA-depression amounts to 1160 m. Fort (2000) thus supposes an increase of the snowline depression from 600 to 1160 m from the very humid to the very arid area. This is absurd. At the same time it is a flagrant contradiction to the results of Burbank et al. (1991) who publish only 100-150 m (a tenth power less!) ELA-depression as for their lowest Pleistocene ice margin position (see above). This is doubly remarkable, because Fort wrote a positive review about the paper of Burbank et al., i.e., described it as being scientifically stable (see Burbank et al. 1991:17).

With regard to the Seti Khola on the Annapurna S-side, Fort (1986) publishes a "Late Glacial glacial extent" (ibid.:108) as far as down to c. 1150 m asl. However, this does not at all fit her Miristi Khola ice margin position at 2800-3000 m asl, classified as lowest LGP ice margin position (LGM c. MIS 3-2?) (Fort 2000 Figure 3). It appears unbelievable that she describes in all seriousness the lowest LGP-(LGM) ice margin position as situated 1600 to 1850 m higher than that of the Late Glacial, particularly since both glacier feeding areas are the same height. This is a further obvious misinterpretation indicating no concept and orientation. In the same paper, the author contradicts herself once more, because 10 pages later (Fort 1986: 118) she refers to the same accumulations in the cross-profile of Ghachok as "debris flow accumulations" (Fort 1986: 118) but not as moraines. During the LGP the Seti Khola glacier actually reached down to 1000 m asl up to the junction of the Seti- and Yamdi Khola (28°16' 20"N/83°57'30"E), 6 km further than Ghachok (Kuhle 1997a: 176). In contrast, Hormann (1974) explained that due to terraces the Seti Khola to a large extent was non-glaciated during the Ice Age. Kuhle describes the gravel terraces as Late Glacial gravel floors covering the LGP-ground moraines only superficially (Kuhle 1982e: 116-119, Photo 100,135, 1983:334-342). In the Madi Khola, Fort (in Owen et al. 1998: 103 Figure 9) determines a lowest past ice margin position at 1200 m near the Taprang settlement. Actually, the lowest LGP- ice margin position was 570 m lower, at 630 m asl (28°12'20N/84°05'20"E), i.e., many kilometres further down-valley (Kuhle 1997a: 391; 1998a). Unfortunately, Fort also quotes wrongly, maintaining that Kuhle (1982e) describes a lowest ice margin at 1500 m in the Thak Khola (Kali Gandaki, Annapurna-Dhaulagiri Himal) near to the Dana settlement (Fort 2000:106, Chapt.4). However, in this valley, the author (Kuhle) found and provided evidence of a lowest LGP-ice margin position about 1000 (910-1010) m asl, 25 km down-valley near to the Ranipauwa settlement, down-valley from the Sansar Khola junction (Aul Khola) (Kuhle 1982e:49-51,152, Abb.8e, 103,104, 1983:123-128). According to that, Fort (in Owen et al. 1998:103 Figure 9) confirms the former results of Kuhle (1980, 1982e) published 13 to 16 years earlier, with her ice margin positions at 1200 m asl in the Madi Khola and – against her earlier descriptions (e.g., Fort 1979,1986) – with 1130 m asl now also in the Seti Khola. Both the valleys are situated immediately E-adjacent to the Thak Khola investigated by Kuhle (see above). At the same time, Fort retracts her results as for a very insignificant LGP-glaciation of the Buri Gandaki (Fort 1979) and approaches the interpretation of Kuhle (1998a: 87) who in the Buri Gandaki establishes a lowest LGP-ice margin at only 680 m asl, at 460 m in the neighboring valleys of the Marsyandi Khola (ibid.87) and at 1000-900 m in the Trisuli river valley (lower Langtang Khola or Bhote Kosi) (2001b: 391,387, Photo 192). This shows that Fort gradually follows Kuhle's opinion as for a very extensive ice stream network and valley glaciation in the Himalaya on the S-margin of Qinghai-Xizang (Tibet), though she originally was absolutely against it. Now her past glacier margins reach more and more down, but she does not concede her new way of thinking in public. This makes the debate on the glacier extension during the Ice Age so unclear.

König (2003:137) shows a further crass inherent contradiction in Bäumler (2001) who describes the lowest past ice margin in the Beni Khola at 2670 m asl at a height of the glacier catchment area of merely 5800 m. The correspondingly old, simultaneous ice margin in the Dudh Koshi, however, he determines immediately E-adjacent at a 1000 m higher position, though the height of the catchment area of the connected Cho Oyu-Everest-Lhotse area in the Dudh Koshi is 1500-1800 m higher. After Kuhle (2006b: Figure 3 below Pro.33; Figure 1 below Deku Khola) the lowest ice margin of the Dudh Koshi parent glacier tongue, which from the confluence of the Imja- and Nangpo Tsangpo (Bote Koshi-) glacier was 38 km long, was situated at c. 900 m asl. The glacier terminal was near to the Inkhu Khola junction (27°28'30"N/86°43'20"E).

The study of Asahi & Watanabe (2000) on the past glaciation of the Kangchenzönga Himal neglects the findings of Kuhle (1990a), Meiners (1999), König (1999) and Dyhrenfurth (1931). So, Asahi et al. describe LGP-ice margin positions fluctuating about 1500 m, i.e., between 3000 and

4500 m asl. Whilst according to their opinion, the currently largest glacier of the massif, the Kangchenzönga glacier, during the LGM did not reach down much further than today, the small Yamatri glacier is supposed to have flowed down c. 1500 m, i.e., to 3000 m asl. The authors do not discuss nor theoretically justify this strikingly small-scale difference of the glacier variations (cf. also König 2003:10). Accordingly, these results are contradictory in itself. Asahi, Tsukamoto et al. (2000) consider 2800 m asl to be the lowest height of the LGP-ice margin in the Ghunsa Khola, whilst Kuhle (1990a) proved that at that time the lowest ice margin was situated at 890 m asl in the Tamur valley. König's (2003:121) reconstruction even reaches down to 650 m, 6 km down-valley, close to Doblan. Asahi et al. explain their assumption by the interruption of the trough form (U-shaped valley form) at 2800 m asl. This is wrong, because glacier striae in V-shaped valleys of the S-flank of the Himalaya as far down as 2095 m asl showed that in the decakilometre-extended ablation areas of the LGP-glaciers in the cross-valleys of the Himalaya-S-face, glacigenic V-shaped valleys are dominant (Kuhle 1980, 1882e: 50,59-60, 1983: 117, 154-155,159; 1991a: 1-8).

Though the results of Asahi et al. (2000) are insufficient and not conclusive, Owen et al. follow this interpretation blindly without presenting their own field investigations. A critical discussion of the author's researches (Kuhle 1990a) or those of Meiners (1999) is also lacking. They have not even taken note of the study of König (1999)!

A further exemplary case – and in this short review of the state of research only paradigmatic cases can be discussed – has to be added. In 1987, the author described in detail an LGP-Indus parent- and outlet glacier which drained the entire c. 125 000 km^2-extended Ice Age Karakorum ice stream network to the W, i.e., flowed farthest down the Indus valley up to c. 850-800 m (Kuhle 1988b: 588,j,k,1989a,1991c,1993b,1996a,1997a,1998a,2001b). Thus, an ELA-depression of 1200-1300 m has been proved. Haserodt (1989) in contrast supposes a much smaller Ice Age (LGP) glaciation of the Karakorum where this part of the Indus valley was without an Indus parent glacier. In this connection he describes moraines in the right Indus valley flank — which the author considers to be ground moraines of the Indus glacier (Kuhle 1996a:Abb.2 No.101, 1997a:Figure28 No.101) — as local end moraines coming from the Barchaloi Gah (valley), a tributary valley of the Nanga Parbat massif, and suggests their transport across the valley-glacier-free Indus main valley (Haserodt 1989: 208). However, this explanation is inevitably wrong, because the medium height of this small Ice Age feeding area of the Barchaloi glacier was only 4200 m. An ELA-depression (depression of the snowline limit) to at least 2650 m asl would have been necessary, so that this tributary glacier could have reached the Indus valley bottom and filled it up to the height of the moraines, i.e., up to 500 m. However, at such a limit of the snowline (ELA), which then could have been lowered by 2150 m, i.e., about 850 m more than the author (Kuhle) has reconstructed, the Indus valley - due to the extreme increase of its feeding area - would have already been filled up anyway by the glacier ice, which flowed together from higher and larger valleys of the entire Karakorum. In the meantime several authors acknowledge this opinion of Kuhle as well as his reconstruction of the LGP-Indus main glacier (e.g., Hormann 2002:125). This is a classic glaciological mistake made by several authors and repeated by Haserodt (1989: e.g., also p.208: rampart-like ridges immediately E of Gor are supposed to be local moraines of the Luthi-Gali-Chamuri hanging glacier; in fact they are moraines of the Indus main valley glacier; cf. Kuhle 1997a: 118). In this connection, Hormann (2002:125) writes: "Kuhle explains that they (the terraces near Gor) are kame terraces and lateral moraines of the Indus glacier. This would result in an important glacier thickness (1500 to 1700 m), whilst Haserodt classifies them as belonging to local glaciers. I tend toward Kuhle's explanation ...". Sharma et al. (1996) made a similar exemplary mistake as a result of missing knowledge of the field and a wrong geomorphological analysis. The cause of this might have been the authors' convenient moving on main roads and -paths on the valley bottom of the Bhagirathi Nala (valley; Garhwal Himalaya) instead of going up the valley flanks to look for glacier traces. Obviously the authors seem to believe that roads have been constructed to render the reconstruction of Ice Age development of glaciers possible. But this is a methodical mistake. Be that as it may, 30 m above the talweg at the roadside near to the Jhala settlement (2300 m asl) they found a probably Late Glacial remnant of ground moraine showing characteristics of an undercut debris flow fan, which they mapped as end moraine and lowest past ice margin position (Sharma et al. 1996: Figures 2,7,14). However, at 3200 m asl, only c. 8 km up-valley of this locality, the author (Kuhle 2006a: 210, Photo 3) mapped far-travelled erratic granite boulders of over 1 m in length, situated 750 m above the gravel floor of the talweg (2500 m asl) in the left flank of the Bhagirathi Nala, 2.3 km S above the Mukha settlement, between the orographic left small side valleys Tel-Gad and Khera Gad (31°01'20"N/ 78°46'50"E). The metre-sized, round-edged granite boulders "swim" in a ground moraine matrix rich in clay. In the underground they lie on outcropping schist. They have been transported from the E over a distance of at least 7 km along the orographic left flank of the Bhagirathi Nala. The glacier trim-line of the last glacial period (Würm-glaciation) was reconstructed with the help of glacigenic flank abrasions and glacigenically truncated spurs indicating a c. 1400 m-thick Bhagirati parent glacier. Its lowest past (probably LGP) glacier tongue end came down to c. 1050 m asl, c. 54-57 km away from this locality, 3 km down-valley of Uttarkashi. There it reached the Slalam Gad (tributary valley) (30°44'N/78°24'E, Kuhle 2006a: 197/198). Thus the result of Sharma et al. (1996) — who determine the postulated ice margin position at 2300 m asl as lowest ice margin position — is wrong and the ice margin has to be classified as belonging to the Late Glacial.

It is rather impossible to discuss the papers of Owen et al. in an argumentative way, because they neither represent the state of research nor an adequate glaciogeomorphologic knowledge. Nece-ssary climatic and glacier-physical information are not given – not even first signs of them. For the main part, geomorphologically uncontrolled dating techniques have been used, which are not applicable for glacigenic forms and accumulations. In none of the Ice Age glacier areas reconstructed worldwide, the authors' working method would have led to results. In addition, the published datings are often in contradiction to each other, so that a glacier-historical connection to the near or far areas cannot be established. An example for this is the ELA-depression of 100 m which Owen et al. (2005:72) reconstructed for the maximum glacier extension of the Batura glacier during the LGP. Immediately on the right above the current tongue of the Batura glacier a 3530 (3483) m high "riegel" (bar mountain) is situated at the exit of the Batura valley (36°28'30"N/74°52'E — 36°29'15"N/74°52' 05"E) partly consisting of evaporites (limestone etc.). It has been polished into the form of a roche moutonnée and is covered with remnants of ground moraine and polymict erratic boulders up to 1.5 m in size. These erratic boulders have been observed at least 800 m above the current terminus of the Batura glacier. Particularly the erratic granite boulders in part are perfectly rounded and lie in very unstable positions. In these positions they are certainly not older than LGP, but probably they belong to the Late Glacial (Stage IV = c. 13.5 Ka). This observation (Kuhle 1996b; 1998a: 90,92, Figure 12; 2006c: Photo 5;Figure 2 No.112) provides evidence of an over 1000 m thick past valley glacier in this cross-profile of the Hunza valley. With regard to the exit of the Batura valley the topographic connection of the findings indicates an Ice Age glacier level at an altitude of at least 4250 m. The joint ice level of the two glaciers (Hunza trunk glacier and Batura glacier), however, was about 4500 m asl. This becomes obvious by the sediments of ground moraine on the orographic left flank of the Hunza valley eastward opposite of Pasu (Kuhle 1996b; 1998a: 90,92, Figure 12; 2006c: Figure 2 No.113; Photo 5). For this an ELA-depression of 700 m is necessary but not only of 100 m as indicated by Owen et al. (2005:72). At other places, moraine boulders on valley flanks of the Karakorum situated higher up the slopes have been dated to be younger than the lower ones — but in terms of the glacier history this is impossible. Summing up, it has to be stated that the interpretations of Owen et al. are not conclusive and cannot be correlated with the geomorphological field evidences in High Asia about the former lowest ice margins and maximum past glacier extents. Besides the necessary method to establish the geomorphological arrangement of the positions, they also neglect the walking in the field to get a certain state of knowledge of the few areas they have investigated. This tradition to form oneself an opinion without knowledge of the field is rather widespread in newer glacier-historical studies. It becomes obvious by a lack of photo-graphical documentations as pieces of evidence. They provide the necessary intersubjective verifiability of the arrangement of the positions and thus are indispensable.

Probably it is a great difference whether one has visited and investigated large parts of High- and Central Asia with comparably well-developed and — preserved glacial forms showing evidences of a simultaneousness of a past glaciation or whether one knows only a few, scattered localities. In the last case one should not dare to infer the whole from merely some spots. However, to demand own caution also from those who have a detailed large-scale overview would not be appropriate. Accordingly, more or less scattered, isolated findings without a concept are facing each other, which totally differ from the data known of the environment and, on top of that, even contradict themselves within one and the same paper. This concerns, e.g., Bäumler (2001) and Fort (1986, 2000) with regard to the Himalaya or Haserodt (1989) as for the Indus glaciation at Nanga Parbat and in the Karakorum (see above) in contrast to the author's coherent conception of a contempo- raneous complete glaciation which fits in the global concept of a 1200 m-ELA-depression without any difficulties. To this belongs, too, that the geomor- phology of High Asia — which according to Kuhle is only understandable in terms of glaciation — ought to be explained by alternatives of the genesis of forms. However, no author tries an explanation such as this — with the exception of the debris flow above-mentioned. But this has already been disproved by erratics situated many 100 to over 1000 m above the talweg. Forms like roches moutonnées, U-shaped valleys with roughenings up to a certain line without a petrographic limit, overdeepenings with or without the formation of lakes found in the whole of High Asia, can only be explained as originating from glacial times. In addition, today these forms of past ages are getting dissected but are not on the point of developing. This proves that in the past the processes were different from today. However, nobody explains which occurrences — except for a glaciation — might have caused them. The periglacial environment exists up to the present; accordingly a change of the conditions is impossible. To sum up: To be without a concept and to have no alternative cannot be an argument against a very extended glaciation in the past as it is defended by Kuhle!

4 Confirmations by Related Disciplines

The glaciogeomorphological observations of the author and their chronological classification (Kuhle 1999a: 45-47) in the arid W-Qinghai-Xizang (Tibet) (Figure 1 No.23 Aksai Chin) are confirmed by the limnological study carried out by Van Campo & Gasse (1993) by means of the Tso Kaerh Hu (Longmu Co; Kuhle 1999a: 265 Photo 196) and the W-adjacent Sumxi Co, which attains only a quarter of its extension. A 10.50 m deep drilling of the latter indicated a basal C14 age of c. 12,700-10,000 yrs BP. Accordingly, it has been classified as belonging to the "Late Glacial period" (Van Campo & Gasse, 1993:306). This corresponds to an initial lake development about 13,500-13,000 yrs BP, i.e., during Stage IV, in the sense of the author (Kuhle 1999a: Table 1). Lake terraces of the Tso Kaerh Hu (Longmu Co) have been dated as being c. 7290,7520 and younger than c. 6000 yrs BP (Van Campo and Gasse 1993:302) (cf. Kuhle 1999a: 265 Photo 196). Thus, postglacial (Holocene; probably also neoglacial) lake levels have already been recorded (Stage V after Kuhle 1999a: Table 1).

As already described (Chapt 1), the climate modelings of Verbitsky & Oglesby (1992) and Marsiat (1994) show that the empirical registration of the global cooling during the LGP indicates the development of a Qinghai-Xizang (Tibetan) inland ice even before the Laurentide and Fennoscandian ice sheets. With regard to the climate this is obvious anyway, because Qinghai-Xizang (Tibet) and its surrounding mountains currently, i.e., during an interglacial period, show permafrost and are situated above the timberline, but this does not apply to the areas of the LGP Laurentide and Fennoscandian ice sheets.

Recently, the Ice Sheet theory of Kuhle (1985a, 1986a, 1987a, 1988b, 1989a, 1995a) has been evidenced, e.g., by geophysical measurements of uplift (Kaufmann & Lambeck 1997; Nesje & Dahl 2001:127). Kaufmann & Lambeck have shown that, on the basis of secular changes in geoid anomaly and free-air gravity anomaly, it is possible to distinguish the amount of glacio-isostatic uplift from uplift caused by tectonic movements. The predictable effects of the melting of an up to 2-km-thick inland ice on the Qinghai-Xizang (Tibetan) plateau are so profound that the current satellite missions CHAMP and GRACE would be able to identify them.

The high viscosity of cold, continental glacier ice with annual temperatures of around -6 to -10°C at the ELA (Kuhle 1988c,1990f,1994a) supports the build-up of ice, provided that there is sufficient precipitation. A modeling of the Qinghai-Xizang (Tibetan) ice for the LGP yielded an ice thickness of c. 1000 m after 10 000 years at a precipitation of only 100 mm/a and an average ELA at 4250 m asl (Kuhle 1997a: 120 Figure 46). The model, undertaken by Herterich and Calov, is based on the empirical data obtained by the author, i.e., the lowest LGP glacier margins, reconstructed with the help of end moraines, and the ascertained ELA depression and estimation of temperature and precipitation in Qinghai-Xizang (Tibet) and its surrounding mountains (Kuhle, Herterich & Calov 1989b). The model is based on the graph of the annual snow balance (100 mm/a) as a function of the height above the ELA and on the contour lines (m asl) of the glacial snow surface (ELA = 4250 m asl) in Qinghai-Xizang (Tibet). It fits the observed heights of the glacial equilibrium line. An average thickness for all of the Qinghai-Xizang (Tibet) ice of approximately 1000 m implies that 2.2-2.4 million km³ of water was bound in the ice sheet of Qinghai-Xizang (Tibet). This corresponds to a lowering of sea level of about 5.4 m (calculated on the basis of data provided by Flint, 1971).

In addition, the intervening High Glacial breakdown of the summer monsoon during the LGP (c. 60-18 Ka) is proof of the inland glaciation of Qinghai-Xizang (Tibet). The current heat-low changed into an LGP cold-high and the summer monsoon stopped. The ceasing of the summer monsoon is proved by the then enlargement of the Tharr desert in India (Seuffert 1973) and the significantly increased influx of dust (dust flux records of Ocean Drilling Program) and accumulation of eolian sediments in the northern Indian Ocean and the Arabian Sea (Sirocko 1989,1995).

On the long term counts what is demonstrated in Figure 3b) and c. The uplift of the Qinghai-Xizang (Tibetan) plateau, as far as it can be reconstructed from the onset of the summer monsoon (Tiedemann et al. 1994, Quade et al. 1989, Prell et al.1992, DeMenocal 1995) and winter monsoon (Jin Xiaochi 1999, Ding Z. et al. 1992, Kukla et al. 1989, An et al. 1990) and, derivable from this, the beginning of an autochthonous glaciation of Qinghai-Xizang (Tibet) from ~2.5 Ma BP onwards, was synchronous with the onset of the global ice ages. Evidence that variations of the summer and winter monsoon intensity documented by marine dust flux records (Emeis et al. 1995, Anderson et al. 1993, Tiedemann et al. 1994, DeMenocal 1995) and loess-palaeosol sequences (Rutter et al. 1993, Xiao et al. 1995, Ding Z. et al. 1992 and 1995) occurred in phase with glacial/ interglacial cycles (40 ky and ~100 ky periods), is a strong pointer to the existence of a Qinghai-Xizang (Tibetan) glaciation (Emeis et al.1995; Anderson et al.1993). Gradual uplift of the Qinghai-Xizang (Tibetan) plateau towards the ELA level enabled an ice sheet of 2.4 million km² to grow from ~1 Ma BP onwards; the resulting cooling effect permitted a maximum expansion of the Nordic lowland ice sheets (-1200 m ELA). The now beginning glacio-isostatic depression, deglaciation and following uplift of the plateau (see above) resulted in the occurrence and duration of interglacial/ glacial cycles (~100 ky periods).

5 The Hypothesis of the Development of the Ice Ages Derived from Empirical Findings

On the basis of empirical findings in the field of the 2.4 million km² extended Qinghai-Xizang (Tibetan) inland ice (Figure 2), the author has formulated a hypothesis of the development of ice ages (Kuhle 1982a, b, d, 1982/1983, 1985a, b, 1986a, c, e, f, 1987a, b, c, e-g, 1988b, d, f, g, i, k, 1989a, 1990d, 1991c, 1993a, b, 1995a, 1996b, 1997a, 1998a, b, d, e, g, h, 1999a-e, 2000a, b, d, e, 2001a, c, 2002a, c, 2003b, 2004c, 2005a, Kuhle et al. 1988b, 1997a, 1998b). With the help of 13 climate measuring stations, radiation- and radiation balance measurements have been carried out between 3300 and 6650 m asl in Qinghai-Xizang (Tibet) (Kuhle et al. 1988a, Kuhle et al. 1989a. They indicate that the subtropical global radiation reaches its highest energies on the High Plateau, thus making Qinghai-Xizang (Tibet) today's most important heating surface of the atmosphere. In glacial times, 70 % of those energies were reflected into space by the snow and firn of the 2.4 million km² extended glacier area covering the upland. As a result, 32 % of the entire global cooling during the ice ages, determined by the albedo, was brought about by this area — now the most significant cooling surface. The uplift of Qinghai-Xizang (Tibet) to a high altitude about 2.8 Ma ago, coincides with the commencement of the Quaternary Ice Ages. When the Plateau was lifted above the snowline (= ELA) and glaciated, this cooling effect gave rise to the global depression of the snowline and to the first Ice Age. The interglacial periods are explained by the glacial-isostatic lowering of Qinghai-Xizang (Tibet) by 650 m (Kuhle et al.1997a; Kuhle 1999a: 272 ~ 274, Figure.38), having the effect that the initial Qinghai-Xizang (Tibet) ice — which had evoked the build-up of the much more extended lowland ices — could completely melt away in a period of positive radiation anomalies (Figure.3a). The next ice age begins, when — because of the glacial-isostatic reverse uplift (see Chapt 5) — the surface of the Plateau has again reached the snowline. This explains why the orbital variations (Milankovitch-theory, Figure 3a) could only have a modifying effect on the Quaternary climate dynamics, but were not primarily time-giving (Figure 3a) and b). as long as Qinghai-Xizang (Tibet) does not glaciate automatically by rising above the snowline, the depression in temperature is not sufficient for initiating a worldwide ice age; if Qinghai-Xizang (Tibet) is glaciated, but not yet lowered isostatically, a warming-up by 4°C might be able to cause an important loss in surface but no deglaciation, so that its cooling effect remains in a maximum intensity. Only a glaciation of the Plateau lowered by isostasy can be removed through a sufficiently strong warming phase, so that interglacial climate conditions are prevailing until a renewed uplift of Qinghai-Xizang (Tibet) sets in up to the altitude of glaciation. The chronology of a Qinghai-Xizang (Tibetan) glaciation since ~2.8 Ma BP and its intensification since ~1 Ma BP has been confirmed by the weakening of the summer monsoon and the intensification of the Asian winter monsoon, respectively, which have been evidenced by marine sediment drillings and loess records (Figure 3c).

Gellert (1991) was the first who discussed in detail the author's Ice Age theory with regard to the influence of the Qinghai-Xizang (Tibetan) inland ice on the atmospheric circulation.

6 The Chronologically Extended and the Chronologically Compressed Glaciation Model

Obviously, it is possible to interpret the maximum High Asian glacier extension by means of a chronologically extended or compressed model. The author does not consider the extended model to be acceptable, which suggests that during the entire Pleistocene up to the LGP past glaciations have taken place in a decreasing extension. Among other things, the reason for his rejection is that a model like this is incompatible with our state of knowledge as to repeated global glaciations of similar extensions. The compressed model of the author, who puts the largest glaciation — which is glaciogeomorphologically preserved up to the present and thus can be evidenced — into the Last Glacial period (LGP, Wuermian Ice Age, MIS 3-2) is methodically appropriate because of at least four reasons:

1) The calculated ELA-depression of 1200-1300 m fits perfectly with the global snowline-depression during the LGP.

2) 10 to 14 glacier stages are globally registered between the LGP and the current ice margins. This number of glacier stages has also been evidenced in High Asia (Kuhle 1982e, 1983). From this arises the consistent picture of one High Glacial (main-glacial) (LGP, i.e., LGM = Last Glacial Maximum), four to six Late Glacial, three Neoglacial (Holocene) and c. five Historical glacier stages. In the case of the extended model, at most seven minor glacier advances with ELA-depressions of merely 100-200 m (see above) remain from the LGP up to the current glacier margins in High Asia. However, obviously this does not stand to the global comparison.

3) During the Last Glacial (LGP) from c. 60-40 Ka, High Asia reached its highest sea level (Figure 3c). Therefore, it would be illogical to suppose a lesser glacier extension than in the middle Pleistocene. For the same reason the middle Pleistocene ice margin positions and end moraines without exception must have been overthrust by the glaciers of the LGP and thus destroyed. This interpretation is confirmed by the nearly complete lack of diagenetically lithified and petrified end moraines in High Asia. In other words this means:

if there were middle Pleistocene end moraines, they would be consolidated and petrified by ascending solutions according to the soil formation — especially under the semiarid and subtropic conditions of High Asia.

4) The glacier traces found in High Asia have only been preserved because they are young. This argument in favour of a very extended glaciation during the LGP in particular applies to the marginal areas of Qinghai-Xizang (Tibet). In these very high and steep mountains — the highest mountains on earth — the modifying geomorpho-dynamics which destroys the past glacier traces actually is the strongest, so that middle Pleistocene forms could be preserved nowhere (Kuhle 1982e; 1983). What has survived are the lowest past moraines situated exactly in the steep and deep valleys of these high mountains. These lowest preserved ice margins provide evidence of a very extended glaciation of High Asia (Figure 2) and, accordingly, of a globally consistent ELA-depression of 1200 m against today.(Figure 3c)

To classify the last extended glaciation of High Asia as being from the LGP we can also refer to absolute datings (Figure 2). Due to radiometric 14C- and TL-datings the glaciation has been settled between younger than 60 Ka and older than 8 Ka. This has already been discussed in detail (Kuhle 1987e, 1994a, 1997a, 1998a,f, Grosswald et al. 1994 etc.).

7 Problems of Dating

In the literature which concerns the dating of the past glaciation of High Asia, some serious mistakes have been found leading to wrong results.

For instance it is a methodical problem to apply weathering to relative dating. This is especially unsuitable, because the hydrothermal decay of the outcropping source rock is able to treat the rock material so heavily even before the weathering out and the glacier transport, that the later moraine boulders crumble away and decay within a few millennia without needing a longer period of weathering. A hydrothermal decay like this has been evidenced by Heydemann & Kuhle (1988) on the N-slope of Mt. Everest and in the trans-Himalaya.

This rapid decay of rock fragments due to a preceding hydrothermal decay of granites and other unstratified rocks often used for surface-datings, naturally makes the Cosmogenic Nuclide Exposure Dating entirely impossible. This applies the more, because the decay of the boulder surfaces is especially rapid.

The following applies to the dating by means of high mountain soils. Unfortunately, the climate-dependent soil development is an indicator which is not very appropriate as for the dating of Quaternary sediments or even moraines in the mountains in general, and especially in the monsoonal-tropical Himalayas. A possibility of calibrating the soil development in the Himalaya, which would admit a comparison, does not exist. The small-scale change of the petrographic compositions of moraine surfaces in the mountains, the small-scale climate change according to the altitude and the change of the topographically-dependent amount of precipitation on the moraine bottoms, and also catabatic winds and special conditions near to glaciers and ice faces as well as this complicated spacious change against the background of the extreme vertical shiftings of the climatic altitude levels during the last 20 000 years with shifts of the snowline by 1500 m, naturally do not render possible an acceptable statement as to the duration of the development of slow and integral processes like weathering and soil development of moraines (cf.Wagner 2005,2007).

Here is a classic example with regard to the absurd datings of past glaciations due to a wrong geomorphological arrangement of the positions: Sharma & Owen (1996:340/341 Tab.4, Figure2) published an OSL-date MIO4 = 84770 BP. It is situated 60 to 70 m above the Bhagirathi river and 15 km up-valley of their date MIO1 = 62894 BP located 30 m above the Bhagirathi river in the Bhagirathi valley (Garhwal Himalaya; cf. Figure1 No.18). MIO1 dates their lowest past ice margin position. But how could the dated gravels have been left behind only 60-70 m (MIO4) above the talweg, despite their having been overthrust by a glacier tongue reaching 15 km further down-valley, which inevitably must have been several 100 metres thick? This is impossible!

Finally, the Cosmogenic Nuclide Exposure Dating (CRN-method) — which can be found in the literature as a fashion — will be described. A rock

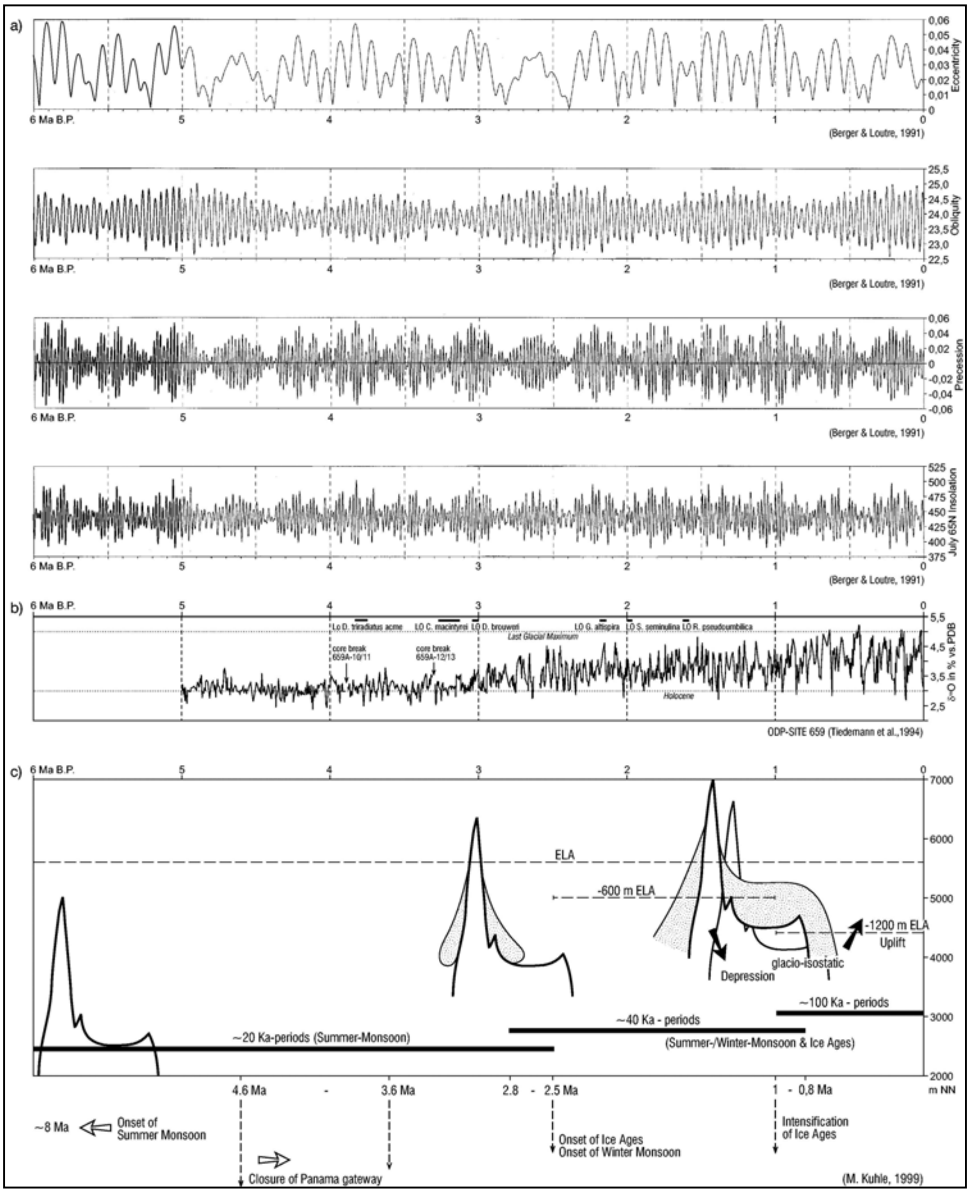

Figure 3 a) Astronomical parameters of the earth's orbit and rotation and corresponding insolation values for 65°N for the last 6 million years according to Berger & Loutre (1991). b) Benthic oxygen isotope records from Ocean Drilling Program Site 659 according to Tiedemann et al. (1994). The fluctuations in the $\delta^{18}O$ content of the foraminifera reflect the fluctuations of the global ice volume, with high values corresponding to the glacials and low values to the interglacials. Neither the beginning nor the intensification of the Quaternary glaciation period is correlated with the insolation (a). c) Synopsis of the uplift and glaciation of the Tibetan plateau in their relation to other geoecological events. A comparison between a) and b) shows that an additional factor apart from orbital variations is required to explain both the start of the ice ages about 2.8 Ma and their increasing intensity from 1 Ma onwards. The closure of the Panama gateway occurred too early to be the terrestrial cause. The uplift of the Tibetan plateau, as far as it can be reconstructed from the onset of the summer and winter monsoons, and, derived from this, the beginning of an autochthonous glaciation of Tibet from ~2.5 Ma BP onwards, were synchronous with the onset of the global ice ages. Evidence that variations of the summer and winter monsoon intensity documented by marine dust flux records and loess-palaeosol sequences on the Chinese loess plateau occurred in phase not with the insolation variation but with glacial-interglacial cycles (40 ky and ~100 ky periods), is a strong pointer to the existence of a Tibetan glaciation. Gradual uplift of the Tibetan Plateau towards the ELA (equilibrium line altitude) level enabled an ice sheet of 2.4 million km² to grow from ~1 Ma BP onwards; the resulting cooling effect permitted a maximum expansion of the Nordic lowland ice sheets (-1200 m ELA). The now beginning glacio-isostatic depression, deglaciation and following rebound of the plateau were responsible for the occurrence and duration of interglacial-glacial cycles (~100 ky periods).

face of a glacier fringe that has already been exposed to cosmogenic nuclides, breaks out. The broken-out rock boulder is rearranged in a complicated, i.e., manifold sediment cascade in the glacier ice, below the glacier ice and within frequently interrupted periods in different lengths as surface moraine on the glacier ice. This is a process that cannot be reconstructed in detail. In the course of this process, the rock boulder is exposed to the radiation of cosmogenic nuclides on all faces, the entirely fresh as well as those which have already been exposed primarily in the rock wall. How long and on which side is also not reconstructable. In addition, the angles of the boulder surfaces to the radiation and, accordingly, the radiation itself are very different. It cannot be ruled out, i.e., it is probable that the originally larger boulder repeatedly shatters during the rearrangement, so that fresh rock surfaces have come into being. Naturally they have been exposed to radiation over a shorter time. At any new glacier regression these boulders are interbedded as lateral moraines and — during a new glacier advance — again taken up and dislocated. This might led to a covering of the boulders in the lateral moraine due to an overwhelming of the moraine or to the boulders' position on the surface. All these are possibilities to influence the surface irradiation of boulders and its intensity, which cannot be reconstructed. In the meantime the lateral mo- raines are undercut by the glacier margin and tipped over, so that a further rearrangement must have taken place. Rearrangements of this sort, i.e., with coverings and exposures, inevitably occurred during the entire Pleistocene glacial and inter- glacial history. During the interglacial periods small glaciers as well as solifluction processes, debris flows and fluvial transport have participated in the rearrangement of the boulders which today can be met in the lowest end moraines. It has to be added that the sea-levels and the duration of all irradiations which took place in the interbeddings are unknown. The end moraines are accumulation forms of a last lowest ice margin. However, the material of these forms — among them the boulders and their surfaces — which have to be dated, has no connection to the age of the forms itself. According to the circumstances they are much older — but the ages differ considerably. Nevertheless, they can also be younger, e.g., due to recent desquamation. A further element of uncertainty is the abrasion of the boulder surfaces during the manifold transport from the break-off up to the last deposit on the lowest end moraine. So, in addition to these uncertainties, the depth of the radiation has been modified. Therefore, part of the reshaping of the rock mass on the boulder surface caused by radiation, in the meantime, has been removed more or less heavily. The varying velocity of this removal by hydrothermal decay has already been mentioned (see above). Furthermore, tectonic stresses, as, e.g., shear structures in the bedrock, force the later velocity of removal (Heydemann & Kuhle 1988:623/624 Figure 18,23). Also, the decay of boulder surfaces has an effect in the same direction, i.e., it is incalculable and distorts the age. Finally, the boulder surfaces on the end moraine undergo further changes with regard to the radiation. Due to down-slope denudation processes, c. 30 to 80 cm of a moraine slope are removed within 1000 yrs. At the same time boulder faces are exposed and buried further down-slope. Because of self-movements the boulders once again undergo a change of their radiation exposure, etc. The radi- ation varies, too, with the vegetation cover and temporary snow cover. Also on the moraine it is different according to the position on the valley floor and the shadow of the valley flanks. Finally, it remains to be explained why even the radiation of cosmogenic nuclides is not constant, but within the last millennia has varied, so that even the last necessary constant is lacking. Owing to this, the Cosmogenic Nuclide Exposure Dating has absolutely no basis.

References

An Z. S., Liu, T.S., Lu, Y.C., Porter, S.C., Kukla, G., Wu, X.H., and Hua, Y.M. 1990. The long-term paleomonsoon variation recorded by the loess-paleosol sequence in central China. *Quaternary International* **7/8**: 91 ~ 95.

Anderson D.M., and Prell, W.L. 1993. A 300 KYR record of upwelling off Oman during the late Quaternary: Evidence of the Asian southwest monsoon. *Paleoceanography* **8:** 193 ~ 208.

Asahi, K., Watanabe, T. 2000. Past and recent glacier fluctuations in Kanchenjunga Himal, Nepal. Journal of the Nepal Geological Society **22**: 481 ~ 490.

Asahi, K., Tsukamoto, S., Aoki, T., Watanabe, T. 2000. Late Quaternary glaciations in Kangchenjunga Himal, eastern Nepal: based on absolute and relativ dating. In: Symposium & Field Workshop on Quaternary Glaciation in Monsoonal Asia, June 5-16, 2000, Chengdu, Abstract: 1.

Bäumler, R. 2001. Vergleichende Untersuchungen in Hochasien und Kamtschatka. Böden als Zeugen der quartären Landschafts- und Klimageschichte. In: Relief Boden Paläoklima, 16. Gebrüder Bornträger, Berlin, Stuttgart: 1 ~ 217.

Berger, A., and Loutre, M.F. 1991. Insolation values for the climate of the last 10 million years. Quaternary Science Reviews **10**: 297 ~ 317.

Bobeck, H. 1937. Die Rolle der Eiszeit in Nordwestiran. Zeitschrift für Gletscherkunde und Glazialgeologie **25:** 130 ~ 183.

Burbank, D.W., Kang Jiang Chen. 1991. Relative Dating of Quaternary Moraines, Rongbuk Valley, Mount Everest, Tibet: Implications for an Ice Sheet on the Tibetan Plateau. Quarternary Research **36:** 1 ~ 18.

Chen Kezao and Bowler, J.M. 1986. Late Pleistocene evolution of salt lakes in the Qaidam basin, Qinghai province, China. *Palaeogeography, Palaeoclimatology, Palaeoecology* **54:** 87 ~ 104.

Cline, R. (ed.). 1981. Climap Projct: Seasonal Reconstructions of the Earth's Surface at the Last Glacial Maximum. Geological Society of America, New York: 1 ~ 18.

Cui Zhijiu. 1964). On the problem of the pleistocene ice-cover patterns in West China. Acta geologica sinica **44**: 229 ~ 245 (chin., engl. Summary).

Dainelli, G. 1922. Studi sul Glaciale. Risultati Geologici e Geografici, Relazioni scientifiche della Spedizione Italiana De Fillipi nell' Himalaya, Caracorum e Turchestan Cinese (1913-1914). Vol. III, Ser. II.

Dainelli, G. & Martinelli, O. 1928. Le condizione fisiche attuali. Risultati Geologici e Geografici, Relazione scientifiche della Speditizione Italiana De Filippi nell'Himalaya, Caracorum e Turchestan Cinese (1913-1914), Ser.II, Bd.IV, Bologna.

DeMenocal, P.B. (1995). Plio-Pleistocene African Climate. *Science* **270:** 53 ~ 59.

Denton, G.H., and Hughes, T. 1981. "The Last Great Ice Sheets." Wiley, New York.

Dyke, A.S. 1979. Glacial and sea level history of Cumberland Peninsula, Baffin Island, Northwest Territories, Canada. *Arctic and Alpine Research* **11:** 179 ~ 202.

Derbyshire, E.; Li Jijun; Perrott, F.A.; Xu Shuying; Waters, R.S. 1984. Quaternary glacial history of the Hunza Valley, Karakoram mountains, Pakistan. In: International Karakoram Project. Vol. 1. (Ed: Miller, K.J.) .

Derbyshire, E.; Owen, L.A.; White, B. 1988. The Quaternary of the Skardu Basin: The problems. Zeitschrift für Geomorphologie (The Neogene of the Himalayas),

Derbyshire. E., Shi Yafeng, Li Jijun, Zheng Benxing, Li Shijie, Wang Jingtai. 1991. Quaternary Glaciation of Tibet. The Geological Evidence. Quaternary Science Reviews **10**: 485 ~ 510.

De Terra, H. 1932. "Geologische Forschungen im westlichen K'unlun und Karakorum-Himalaya." Wiss. Ergebnisse der Dr. Trinkler'schen Zentralasien Expedition, **2**, Berlin.

De Terra, H.; Paterson, T.T. 1939. Studies on the Ice-Age in India and associated human cultures. Vol. 493. Carnegie Institut, 1 ~ 354.

Ding Zhongli, Rutter, N., Han Jingtai, and Liu Tungsheng. 1992. A coupled environmental system formed at about 2.5 Ma in East Asia. *Palaeogeography, Palaeoclimatology, Palaeoecology* **94**: 223 ~ 242.

Ding Zhongli, Liu Tungsheng, Rutter,N., Zhiwei Yu, Zhengtang Guo, and Rixiang Zhu. 1995. Ice-Volume Forcing of East Asian Winter Monsoon Variations in the Past 800,000 Years. *Quaternary Research* **44**: 149 ~ 159.

Drozdowski, E. 1992. Deglaciation of the Northern Foothills in the East Kunlun Mts. Geographia Polonica 60: 33 ~ 40.

Dyhrenfurth, G. O. 1931. Der Himalaya — Unsere Expedition 1930. Verlag Scherl, Berlin: 1 ~ 380.

Emeis, K.-Ch., Anderson, D.M., Doose, H., Kroon, D., and Schulz-Bull, D. 1995. Sea-Surface Temperatures and the History of Monsoon Upwelling in the Northwest Arabian Sea during the Last 500,000 Years. *Quaternary Research* **43**: 355 ~ 361.

England, J. 1999. Coalescent Greenland and Innuitian ice during the Last Glacial Maximum: revising the Quaternary of the Canadian High Arctic. *Quaternary Science Reviews* **18**: 421 ~ 456.

Ficker, H.v. 1925. Die Höhe der Schneegrenze in den Pamirgebieten. Meteorologische Zeitschrift **42**: 276 ~ 277.

Ficker, H.v 1933. Die eiszeitliche Vergletscherung der nordwestlichen Pamirgebiete. Sitzungsbericht der Preussischen Akademie der Wissenschaften, Berlin, Math.-phys. Kl., 61 ~ 86.

Flint, R.F., 1971. Glacial and Quaternary Geology. John Wiley and Sons, Inc.**,** New York, 1 ~ 892.

Flohn, W. (1959. Bemerkungen zur Klimatologie von Hochasien. Aktuelle Schneegrenze und Sommerklima. Akademie der Wissenschaften und der Literatur Mainz, Abhandlungen der Mathematisch-Naturwissenschaftlichen Klasse 14 (Jahrgang 1959), 309 ~ 331.

Flohn, H. 1981. The elevated heat source of the Tibetan highlands and its role for the large scale atmospheric circulation. *In* "Geological and Ecological Studies of the Qinghai-Xizang Plateau." (Science Press, Beijing, Gordon and Breach, New York) **2**: 1463 ~ 1469.

Flohn, W. 1982. Recent investigations on the Climatic role of the Tibetian Highlands: Now and in the Late Cenozoic. Sitzungsbericht der Braunschweigischen Wissenschaftlichen Gesellschaft 6 ("Die 1. Chinesisch-Deutsche Tibet-Expedition 1981", Göttingen, 1981), 78 ~ 79.

Fort, M. 1979. Etudes sur le Quaternaire de l'Himlalaya: la houte vallee de la Buri Gandaki, Nepal. Editions du ENRS, Paris, 232pp.

Fort, M. 1986. Glacial extension and catastophic dynamics along the Annapurna front, Nepal Himalaya. In: Intern. Symp. über Tibet u. Hochasien (8.-11. Oktober 1985), Geogr. Inst. Univ. Göttingen, Göttinger Geogr. Abh. Vol. 81. (Ed: Kuhle, M.) (48) Göttingen: 105 ~ 125.

Fort, M. 2000. Glaciers and mass wasting processes: their influence on the shaping of the Kali Gandaki valley (higher Himalaya of Nepral). Quarternary International **65/66**: 101 ~ 119.

Frenzel, B. 1959. Die Vegetations- und Landschaftszonen Nord-Eurasiens während der letzten Eiszeit und während der postglazialen Wärmezeit. Teil I, Allgemeine Grundlagen. Akademie der Wissenschaften und der Literatur Mainz, Abh. d. Math. nat. wiss. Kl. 13 (Jahrgang 59. 937 ~ 1099. Mainz.

Frenzel, B. 1960. Die Vegetations- und Landschaftszonen Nord-Eurasiens während der letzten Eiszeit und während der postglazialen Wärmezeit. Teil II, Rekonstruktionsverssuch der letzteiszeitlichen und wärmezeitlichen Vegetation Nord-Eurasiens. Akademie der Wissenschaften und der Literatur Mainz, Abh. d. Math. nat. wiss. Kl. 6 (Jahrgang 60. 289 ~ 453. Mainz.

Gellert, J.F. 1991. Pleistozän-kaltzeitliche Vergletscherungen im Hochland von Tibet und im Südafrikanischen Kapgebirge. Pleistozän-kaltzeitliche Klimadynamik und Paläogeographie in Indien und Südafrika. Eiszeitalter und Gegenwart **41**: 141 ~ 145.

Goudie, A.S.; Brunsden, D.; Collins, D.N.; Derbyshire, E.; Ferguson, R.I.; Hasmet, Z.; Jones, D.K.C.; Perrott, F.A.; Said, M.; Waters, R.S.; Whalley, W.B. 1984. The geomorphology of the Hunza Valley, Karakoram Mountains, Pakistan. In: International Karakoram Project. Vol. 1. (Ed: Miller, K.J.) .

Grosswald, M.G., Kuhle, M. 1994. Impact of Glaciations on Lake Baikal. In: Shoji Horie, Kazuhiro Toyoda (IPPCCE) (eds..

International Project on Paleolimnology and Late Cenozoic Climate No. 8. Universitätsverlag Wagner, Innsbruck: 48 ~ 60.

Grosswald, M.G., Kuhle, M., Fastook, J.L. 1994. Würm Glaciation of Lake Issyk-Kul Area, Tian Shan Mts.: A Case Study in Glacial History of Central Asia. In: GeoJournal 33 (2/3), Tibet and High Asia, Results of the Sino-German and Russian-German Joint Expeditions (III). Kuhle, M. (ed.); Kluwer, Dordrecht/ Boston/ London: 273 ~ 310.

Hagedorn, H.; Haars, W.; Busche, D.; Förster, H. 1974. Zur Geomorphologie des Shir-Kuh-Massivs (Zentral-Iran). Marburger Geographische Schriften **62**: 39 ~ 48.

Handel-Mazzetti, F. H. 1927. Das nordostbirmanische-westyünnanische Hoch-gebirgsgebiet. - Karsten-Schenck, Vegetationsbilder, **17**: 7 ~ 8.

Han Tonglin (1991. The great Qinghai-Xizang Ice Sheet. Geological Publishing House, Peking, 1 ~ 96.

Han Tonglin (1999. Field evidence of the quarternary continental glacial sheet on the Qinghau-Xizang Plateau. In: Zheng Benxing, Shen Yongping (eds.. Problems on Quaternary Glaciation Research in the Qinghai-Tibetan Plateau. Contributions Collections of Research on Quaternary Glaciation and Environments in the Qinghai-Tibetan Plateau. Lanzhou Institute of Glaciology and Geocryology, Chinese Academy of Sciences, Lanzhou, China (in Chinese with abstract in English), 302 ~ 312.

Haserodt, K. 1989. Zur pleistozänen und postglazialen Vergletscherung zwischen Hindukusch, Karakorum und Westhimalaya.- Beiträge und Materialien zur Regionalen Geographie, **2**: 182 ~ 233.

Hebenstreit, R. 1999) Glazialformen im nordöstlichen Teil des zentralen Tibet-Plateaus zwischen Kunlun Shan und Fenghuo Shan (Provinz Qinghai, VR China). Unbupl. Diplomarbeit Depart. of Geography and High Mountain Geomorphology, Geogr. Inst. Universität Göttingen, Germany, 1 ~ 133.

Heydemann, A. & Kuhle, M. 1988. The Petrography of Southern Tibet - Results of Microskopic and X-Ray Analyses of Rock Samples from the 1984 Expedition Area (Transhimalaya to Mt. Everest N Slope). *GeoJournal* **17** (4) (Kuhle M. & Wang Wenjing (eds), Tibet and High Asia (I), Results of the Sino-German Joint Expeditions. 615 ~ 625.

Hedin, S. 1904-1907. Scientific results of a journey in central Asia 1899-1902. Vol. III-V. Stockholm Lith. Inst. of the Gen. Staff of the Swed. Army.

Hedin, S. 1909/1912. Transhimalaya. 3 Bd., Brockhaus, Leipzig, Wiesbaden.

Hedin, S. 1917/1922. Southern Tibet. Discoveries in former times compared with my own researches in 1906-1908. Vo. I-IX, Leipzig.

Heuberger, H. 1956. Beobachtungen über die heutige und eiszeitliche Vergletscherung in Ostnepal. Zeitschrift für Gletscherkunde und Glazialgeologie 3: 349 ~ 364.

Hövermann, J.; Süssenberger, H. 1986. Zur Klimageschichte Hoch- und Ostasiens. Berliner Geographische Studien **20**: 173 ~ 186.

Hövermann, J.; Hövermann, E. 1991. Pleistocene and holocene geomorphological features between the Kunlun Mountains and the Taklamakan Desert. Die Erde, Ergänzungsheft **6**: 51 ~ 72.

Hövermann, J.; Lehmkuhl, F. 1993. Bemerkungen zur eiszeitlichen Vergletscherung Tibets. Mitteilungen der Geographischen Gesellschaft zu Lübeck **58**: 137 ~ 158.

Hormann, K. 1974. Die Terrassen an der Seti Khola – ein Beitrag zur Quartären Morphogenese in Zentralnepal. Erdkunde **28** (3. 161 ~ 176.

Hormann, K. 2002. Eiszeitliche Vergletscherung, junge Tektonik und Fluss-Längsprofilentwicklung im Industal in Nordpakistan. In: Beiträge zur Physischen Geographie – Festschrift zum 75. Geburtstag von Friedrich Wilhelm.- Münchener Geographische Abhandlung A52, München: 117 ~ 138.

Huntington, A. 1906. Pangong, a glacial lake in the Tibetan Plateau.-Journal of Geology, **14**: 599 ~ 623.

Iturrizaga, L. 1999a. Die Schuttkörper in Hochasien – Eine geomorphologische Bestandsaufnahme und Typologie postglazialer Hochgebirgsschuttkörper im Hinddukush, Karakorum und Himalaya. In: Göttinger Geographische Abhandlungen, **106**: 1 ~ 326.

Iturrizaga, L. 1999b. Typical debris accumulation forms and formations in High Asia. A glacial-history-based concept of the origin of Postglacial debris accumulation landscapes in subtropical high mountains with selected examples from the Hindu Kush, the Karakoram and the Himalayas. GeoJournal 47 (1/2), Tibet and High Asia V, Ed. Kuhle, M.), 277 ~ 339.

Iturrizaga, L. 2001. Lateroglacial valleys and landforms in the Karakorum Mountains (Pakistan). GeoJournal 54 (nos. 2-4) 55 (no.1), Tibet and High Asia VI, Glaciogeomorphology and Prehistoric Glaciation in the Karakorum and Himalaya, Ed: Kuhle, M.), 397 ~ 428.

Iturrizaga, L. 2006. Transglacial Landforms in the Karakoram (Pakistan. A Case Study from the Shimshal Valley. In: Karakoram in Transition – Culture, Development and Ecology in the Hunza Valley. (Ed: Kreutzmann, H.) Saijid, A., Oxford University Press, Karachi, Pakistan, 96 ~ 108.

Jacobsen, J.P. 1990. Die Vergletscherungsgeschichte des Manaslu Himalaya's und ihre klimatische Ausdeutung. Geo Aktuell Forschungsarbeiten **1**: 1 ~ 82.

Jin Xiaochi (1999). Sedimentological response to the uplifting of the West Kunlun in the Cenozoic. *Terra Nostra* **2**: 79.

Kaufmann, G., Lambeck, K. 1997. Implications of Late Pleistocene Glaciation of the Tibetan Plateau for Present-Day Uplift Rates and Gravity Anomalies. Quaternary Research **48**: 267 ~ 279.

Klebelsberg, R.v (1922. Beiträge zur Geologie Westturkestans. In: Ergebnisse der Expedition des DÖAV im Jahre 1913.

Klute, F. 1928. Die Bedeutung der Depression der Schneegrenze für eiszeitliche Probleme. Zeitschrift für Gletscherkunde, für Eiszeitforschung und Geschichte des Klimas **16:** 70 ~ 93.

Klute, F. 1930. Verschiebung der Klimagebiete der letzten Eiszeit. Petermanns Geographische Mitteilungen. Ergänzungsband **209**: 166 ~ 182.

König, O. 1999. Preliminary results on the last high-glacial glaciation of the Rolwaling Himal and the Kangchenjunga Himal (Nepal, East-Himalaya).- GeoJournal 47 (1-2, (Results of Investigations into High Mountain Geomorphology, Paleo-Glaciology and Climatology of the Pleistocene), Tibet and High Asia (V), Ed: Kuhle, M.), 373-384. (Kluwer Academic Publishers)

König, O. 2001. Investigation on the Quarternary Glaciation in the Khumbu Himal (Nepal, East-Himalaya).- GeoJournal 54 (1-4), 55 (1) (Glaciogeomorphology and Prehistoric Glaciation in the Karakorum and Himalaya. Tibet and High Asia (VI), Ed: Kuhle, M.), 451-469. (Kluwer Academic Publishers)

König, O. 2003. Zur Vergletscherungsgeschichte des Rolwaling Himal und des Kangchenjunga Himal (Nepal, Himalaya Südabdachung). http: // webdoc. sub. gwdg. De / diss / 2003 / Koenig / index. html. Göttingen; 257 pp.

König, O. 2004. The glaciation of the Rolwaling Himal and the Kangchendjunga Himal during the Last Glacial Maximum (Nepal, E-Himalaya). Development in Quaternary Science 2c (Quaternary Glaciation - Extent and Chronology, Part III: South America, Asia, Africa, Australia, Antarctica, Eds: Ehlers, J.; Gibbard, P.L.) (Elsevier B.V., Amsterdam. 279 ~ 284.

Kuhle, M. 1974. Vorläufige Ausführungen morphologischer Feldarbeitsergebnisse aus den SE-Iranischen Hochgebirgen am Beispiel des Kuh-i-Jupar. Zeitschrift für Geomorphologie, N.F. **18** (4), 472 ~ 483.

Kuhle, M. 1976. Beiträge zur Quartärgeomorphologie SE-Iranischer Hochgebirge. Die quartäre Vergletscherung des Kuh-i-Jupar. Göttinger Geographische Abhandlungen 67, Bd. I: 1-209; Bd. II: 1 ~ 105.

Kuhle, M. 1980. Klimageomorphologische Untersuchungen in der Dhaulagiri und Annapurna-Gruppe (Zentraler Himalaya). In: Tagungsbericht und wissenschaftliche Abhandlungen des 42. Deutschen Geographentag Göttingen. Steiner, Wiesbaden, 244

~ 247.
Kuhle, M. 1982a. Erste Chinesisch-Deutsche Gemeinschaftsexpedition nach NE-Tibet und in die Massive des Kuen-Lun-Gebirges 1981. Ein Expeditions- und vorläufiger Forschungsbericht. In: Tagungsber. und wiss. Abhandlungen des 43. Deutschen Geographentages Mannheim 1981. (Eds: Hagedorn, H.; Giessner, K.) Steiner, Wiesbaden, 63 ~ 82.
Kuhle, M. 1982b. An expediton to an unexplored region of Tibet. German and Chinese research in the mountains. Reports of the DFG, German Research **3**: 9 ~ 12.
Kuhle, M. 1982c. Periglazial- und Glazialformen und -prozesse in NE-Tibet. Sitzungsberichte und Mitteilungen der Braunschweigischen Wissenschaftlichen Gesellschaft, Sonderheft 6 (Die Chinesisch/Deutsche Tibet-Expedition 1981, Braunschweig-Symposium vom 14.-16.04.1982), 19 ~ 24.
Kuhle, M. 1982d. Was spricht für eine pleistozäne Inlandvereisung HochTibets? Sitzungsberichte und Mitteilungen der Braunschweigischen Wissenschaftlichen Gesellschaft 6 (Sonderband: Die Chinesisch/Deutsche Tibet-Expedition 1981, Braunschweig-Symposium vom 14.-16.04.1982), 68 ~ 77.
Kuhle, M. 1982e. Der Dhaulagiri- und Annapurna-Himalaya. Ein Beitrag zur Geomorphologie extremer Hochgebirge. Zeitschrift für Geomorphologie Supplement 41 (Suppl. Bd.), Bd. I (Text. 1-229; Bd. II (Abb.. 1-183 und Geomorph. Karte 1: 85 000.
Kuhle, M. 1982/1983. A New Expedition in Tibet - a Contribution to Climatology and High Mountain Research. Universitas 25 (1), 59-63 (also in german and spanisch language).
Kuhle, M. 1983. Der Dhaulagiri- und Annapurna-Himalaya. Ein Beitrag zur Geomorphologie extremer Hochgebirge. Empirische Grundlage; Ergänzungsbd. III. Zeitschrift für Geomorphologie 41 (Suppl. Bd.), 1 ~ 383.
Kuhle, M. 1984a. Das Mt. Chomolungma-Massiv (Sagarmatha- oder Mt. Everest-Massiv (27°59'N/86°56'E) - Zur Morphologie des Himalaya zwischen Tibetischem Hochland und S-lichen Vorketten. Geographische Rundschau 36, 298 and 300.
Kuhle, M. 1984b. Auswertung von Spacelabaufnahmen aus Hochasien: Die Kuen-Lun-N-Abdachung zur Tsaidam-Depression (ca. 35°45'-37°40'N/91°30'-92°52'E) - Ausdeutung einer Satellitenphotographie über Feldarbeitsbefunde benachbarter Areale mit analoger geomorphologischer Sequenz. Geographische Rundschau 36, 299 and 301.
Kuhle, M. 1984c. Zur Geomorphologie Tibets, Bortensander als Kennformen semiarider Vorlandvergletscherungen. Berliner Geographische Abhandlungen 36 (Ferd. v. Richthofen-Symposium 1983), Berlin, 127 ~ 138.
Kuhle, M. 1984d. Former Glacier Stades in Mountain Area Surrounding Tibet. In: 25. Congres International de Geographie Paris 1984 (27.-31.08.84), Abstracts. Vol. Tome II Thèmes 21 à 31 et 40.
Kuhle, M. 1985a. Glaciation Research in the Himalayas: A New Ice Age Theory. Universitas **27** (4), 281 ~ 294 (also in german and spanisch language).
Kuhle, M. 1985b. Ein subtropisches Inlandeis als Eiszeitauslöser. SüdTibet- und Mt. Everest-Expedition 1984. Georgia Augusta, Nachrichten aus der Universität Göttingen **42**: 35 ~ 51.
Kuhle, M. 1986a. Die Vergletscherung Tibets und die Entstehung von Eiszeiten. Spektrum der Wissenschaften; Scientific American **9/86**: 42 ~ 54.
Kuhle, M. 1986b. Former glacial stades in the mountain areas surrounding Tibet - In the Himalayas (27-29°N: Dhaulagiri-, Annapurna-, Cho Qyu-, Gyachung Kang-areas) in the south and in the Kuen Lun and Quilian Shan (34-38°N: Animachin, Kakitu) in the north. In: Nepal-Himalaya - Geo-Ecological Perspektives. Eds: Joshi, S.C.; Haigh, M.J.; Pangtey, Y.P.S.; Joshi, D.R.; Dani, D.D.) "Himalayan Research Group", 437 ~ 473.
Kuhle, M. 1986c. New Research in High Asia, Tibet and the Himalayas (The International Symposium on Tibet and High Asia, October 8.-11. 1985 in Göttingen). GeoJournal **12** (3), 341 ~ 343.
Kuhle, M. 1986d. The South Tibet and Mount Everest-Expedition 1984 - Geographical Investigations in Upland Asia. (Die SüdTibet und Mt.-Everest-Expedition 1984 - Geographische Untersuchungen in Hochasien.) Wissenschaftlicher Tonfilm, 45 min. Farbtonfilm Film D 1607, Produktion des Instituts für den wissenschaftlichen Film (IWF). Göttingen (German and English Version).
Kuhle, M. 1986e. The South Tibet and Mt. Everest-Expedition 1984 – A Subtropical Inland Ice (Ice Sheet) as Ice Age Trigger. Universitas **41** (1), 64 ~ 78 (also in german and spanish language).
Kuhle, M. 1986f. Die SüdTibet und Mt.-Everest-Expedition 1984 - Geographische Untersuchungen in Hochasien. Publikationen zu wissenschaftlichen Filmen des Institutes für den Wissenschaftlichen Film (IWF), Sektion Geographie D 1607, 1 ~ 37.
Kuhle, M. 1987a. Subtropical Mountain- and Highland-Glaciation as Ice Age Triggers and the Waning of the Glacial Periods in the Pleistocene. GeoJournal **14** (4), 393 ~ 421.
Kuhle, M. 1987b. The Pleistocene Glaciation of Tibet and its Impact on the Global Climate. In: XII International Congress INQUA 1987 Ottawa, July 31 - August 9, 1987, Canada. Programme with Abstracts. INQUA, Ottawa, 204.
Kuhle, M. 1987c. The pleistocene Glaciation of Tibet and the Onset of Ice Ages - an Autocycle Hypothesis. Meeting of the IGU-Working Group on Geomorphological Survey and Mapping in Poland; Thorun 25-30 May, 1987. Polish Academy of Science; Abstract.
Kuhle, M. 1987d. Glacial, Nival and Periglacial Environments in Northeastern Quinghai-Xizang-Plateau. In: Reports on the Northeastern part of the Quinhai-Xizang (Tibet)-Plateau by the Sino-West-German Scientific Expedition 1981. (Eds: Hövermann, J.; Wenjing, W.) Science Press, Beijing, China, 176 ~ 244.
Kuhle, M. 1987e. The Problem of a Pleistocene Inland Glaciation of the Northeastern Qinghai-Xizang-Plateau. In: Reports on the Northeastern Part of Quinghai-Xizang (Tibet)-Plateau by the Sino-German Scientific Expedition 1981. (Eds: Hövermann, J.; Wenjing, W.) Science Press, Beijing, China, 250 ~ 315.
Kuhle, M. 1987f. Die Rekonstruktion des kaltzeitlichen Tibet-Eises und Energiebilanzmessungen bis 6650m ü.M. als Basis einer reliefspezifischen Eiszeittheorie. In: Tagungsbericht und wissenschaftliche Abhandlungen des 46. Deutschen Geographentages München 1987. Vol. 46. Ak-Sitzung "Neuere Forschungen in der Klimatologie". (Ed: Becker, H.) Steiner, Stuttgart, 600 ~ 601.
Kuhle, M. 1987g. Die Wiege der Eiszeit. Geo **1987** (2), 80 ~ 94.
Kuhle, M. 1987h. Absolute Datierungen zur jüngeren Gletschergeschichte im Mt Everest-Gebiet und die mathematische Korrektur von Schneegrenzberechnungen. In: Tagungsbericht und wissenschaftliche Abhandlungen des 45. Deutschen Geographentages Berlin 1985. (Ed: Hütteroth, W.-D.) Steiner, Stuttgart, 200 ~ 208.
Kuhle, M. 1988a. Geomorphological Findings on the Build-up of Pleistocene Glaciation in Southern Tibet, and on the Problem of Inland Ice. Results of the Shisha Pangma and Mt. Everest Expedition 1984. In: GeoJournal 17 (4), Tibet and High-Asia, Results of the Sino-German Joint Expeditions (I). Kuhle, M., Wang Wenjing (eds.); Kluwer, Dordrecht/Boston/London: 457 ~ 513.
Kuhle, M. 1988b. The Pleistocene Glaciation of Tibet and the Onset of Ice Ages- An Autocycle Hypothesis. In: GeoJournal 17 (4), Tibet and High-Asia. Results of the Sino-German Joint Expeditions (I). Kuhle, M., Wang Wenjing (eds.); Kluwer, Dordrecht/ Boston/ London: 581 ~ 596.
Kuhle, M. 1988c. Die eiszeitliche Vergletscherung W-Tibets zwischen Karakorum und Tarim-Becken und ihr Einfluß auf die globale Energiebilanz. In: Geographische Zeitschrift **76** (3): 135 ~ 148.
Kuhle, M. 1988d. Eine reliefspezifische Eiszeittheorie. Nachweis einer Tibetischen Inlandvereisung und ihrer energetischen Konsequenzen. In: Die Geowissenschaften **6** (5. 142 ~ 150.

Kuhle, M. 1988e. Zur Geomorphologie der nivalen und subnivalen Höhenstufe in der Karakorum-N-Abdachung zwischen Shaksgam-Tal und K2 Nordsporn: Die quartäre Vergletscherung und ihre geoökologische Konsequenz. In: Becker, H. ed.. Tagungsbericht und wissenschaftliche Abhandlung des 46. Deutschen Geographentag 1987 München. Steiner, Stuttgart: 413 ~ 419.

Kuhle, M. 1988f. Heutige und eiszeitliche Vergletscherung HochTibets. Ergebnisse der SüdTibet- und Mt. Everest Expedition 1984. In: Publikationen zu wissenschaftlichen Filmen des Institutes für den Wissenschaftlichen Film (IWF) Sektion Naturwissenschaften, Serie 10, D 1649; Göttingen: 1 ~ 36.

Kuhle, M. 1988g. Subtropical Mountain- and Highland-Glaciation as Ice Age Triggers and the Waning of the Glacial Periods in the Pleistocene. In: Chinese Translation Bulletin of Glaciology and Geocryology **5** (4): 1 ~ 17 (in Chinese language).

Kuhle, M. 1988h. Topography as a Fundamental Element of Glacial Systems. A New Approach to ELA-Calculation and Typological Classification of Paleo- and Recent Glaciation. In: GeoJournal 17 (4), Tibet and High-Asia, Results of the Sino-German Joint Expeditions (I). Kuhle, M., Wang Wenjing (eds.); Kluwer, Dordrecht/ Boston/ London: 545 ~ 568.

Kuhle, M. 1988i. Zur Auslöserrolle Tibets bei der Entstehung von Eiszeiten. In: Spektrum der Wissenschaften; Scientific American **1/88**: 16 ~ 20.

Kuhle, M. 1988j. Letzteiszeitliche Gletscherausdehnung vom NW-Karakorum bis zum Nanga Parbat (Hunza-Gilgit- und Indusgletschersystem). In: Becker, H. ed.. Tagungsbericht und wissenschaftliche Abhandlungen des 46. Deutschen Geographentages München 1987. AK- Sitzung "Neueste physisch-geographische Forschungsergebnisse aus HochTibet und angrenzenden Gebieten". Steiner, Stuttgart: 606 ~ 607.

Kuhle, M. 1988k. The Pleistocene Glaciation of Tibet and the Onset of Ice Ages — An Autocyclic Hypothesis.- In: International Congress "The Neogene of Karakoram and Himalayas" March 21th — 23rd, 1988. p. 11; Leicester, UK; Abstract (Department of Geography, University of Leicester).

Kuhle, M. 1988k. Recent and Ice-Age Glaciation of Upland Asia — Findings of the 1984 South Tibet and Mount Everest Expedition. Heutige und eiszeitliche Vergletscherung HochTibets. Ergebnisse der SüdTibet- und Mt.-Everest-Expedition 1984.) Wissenschaftlicher Tonfilm, 43,5 min. Farbtonfilm Film D 1649, Produktion des Instituts für den wissenschaftlichen Film (IWF), Göttingen. German and English version)

Kuhle, M.; Jacobsen, J.P. 1988a. On the Geoecology of Southern Tibet — Measurements of Climate Parameters including Surface- and Soil-Temperatures in Debris, Rock, Snow, Firn and Ice during the South Tibet- and Mt. Everest Expedition in 1984. GeoJournal 17 (4, Tibet and High-Asia, Results of the Sino-German Joint Expeditions (I), Eds: Kuhle, M.; Wang Wenjing), 597 ~ 615.

Kuhle, M.; Reidt, L. 1988b. Eiszeiten und ihre Entstehung: In "Aktuelle Wissenschaft", Hörfunksendung 40 min.

Kuhle, M.; Lüdecke, C. 1989a. Radiation Budget and Energy Flux in Glaciated Areas of High Asia. In: Verhandlungsband "International Conference on Mountain Meteorology and Alpex", 5.-9. June 1989, Garmisch-Partenkirchen, FRG; Abstract Vol..

Kuhle, M. 1989a. Die Inlandvereisung Tibets als Basis einer in der Globalstrahlungsgeometrie fußenden, reliefspezifischen Eiszeittheorie. In: Petermanns Geographische Mitteilungen 133 (4); Justus Perthes Verlag, Gotha: 265 ~ 285.

Kuhle, M. 1989b. Ice-Marginal Ramps: An Indicator of Semiarid Piedmont Glaciations. In: GeoJournal 18; Kluwer, Dordrecht/ Boston/ London: 223 ~ 238.

Kuhle, M., Herterich, K., Calov, R. 1989b. On the Ice Age Glaciation of the Tibetan Highlands and its Transformation into a 3-D Model. In: GeoJournal 19 (2); Kluwer, Dordrecht/ Boston/ London: 201 ~ 206.

Kuhle, M. 1990a. New Data on the Pleistocene Glacial Cover of the Southern Border of Tibet: The Glaciation of the Kangchendzönga Massif (8585m, E-Himalaya). In: GeoJournal 20; Kluwer, Dordrecht/ Boston/ London: 415 ~ 421.

Kuhle, M. 1990b. The Probability of Proof in Geomorphology - an Example of the Application of Information Theory to a New Kind of Glacigenic Morphological Type, the Ice-marginal Ramp (Bortensander). In: GeoJournal 21 (3); Kluwer, Dordrecht/ Boston/ London: 195 ~ 222.

Kuhle, M. 1990c. Geographische Forschungen in Hochasien. Neue Daten zur Rekonstruktion des pleistozänen Tibetischen Inlandeises - Befunde der Expedition 1989. In: Jahrbuch der Marburger Geographischen Gesellschaft und des Fachbereiches Geographie der Phillipps-Universität, Marburg/Lahn: 19 ~ 22.

Kuhle, M. 1990d. La glaciacion del Tibet y sus repererсusiones globales para el clima. In: Universitas **32**: 71 ~ 85.

Kuhle, M. 1990e. Bericht über Beiträge der Arbeitskreissitzung: Neue Forschungen in Hochasien (Arbeitskreis Hochasien) auf dem Deutschen Geographentag in Saarbrücken 1989. In: Geographische Rundschau **42** (6): 356 ~ 357.

Kuhle, M. 1990f. The Cold Deserts of High Asia (Tibet and Contiguous Mountains). GeoJournal **20** (3), 319 ~ 323.

Kuhle, M. 1991a. Glazialgeomorphologie. Wissenschaftliche Buchgesellschaft, Darmstadt: 213 S. ISBN 3-534-06892-0).

Kuhle, M. 1991b. Observations Supporting the Pleistocene Inland Glaciation of High Asia. In: GeoJournal 25 (2/3), Tibet and High Asia, Results of the Sino-German Joint Expeditons (II). Kuhle, M., Xu Daoming (eds.); Kluwer, Dordrecht/ Boston/ London: 133 ~ 233.

Kuhle, M. 1991c. Die Vergletscherung Tibets und ihre Bedeutung für die Geschichte des nordhemisphärischen Inlandeises. In: Sitzungsberichte der Akademie der Wissenschaften und der Literatur Mainz Paläoklimaforschung 1, Klimageschichtliche Probleme der letzten 130 000 Jahre. Frenzel, B. ed.. 293 ~ 306.

Kuhle, M. 1991d. Kurzbericht über die Tibet-Exkursion 14 A im Rahmen XIII. INQUA Kongresses 1991 in Peking. Eiszeitalter und Gegenwart **44**: 129 ~ 131.

Kuhle, M. 1993a. Eine Autozyklentheorie zur Entstehung und Abfolge der quartären Kalt- und Warmzeiten auf der Grundlage epirogener und glazialisostatischer Bewegungsinterferenzen im Bereich des Tibetischen Hochlandes. In: Petermanns Geographische Mitteilungen 137 (3); Justus Perthes Verlag, Gotha: 133 ~ 152.

Kuhle, M. 1993b. The Pleistocene Glaciation of the Himalaya and Tibet and its Impact on the Global Climate: A Relief-specific Ice Age Theory. In: Journal of the Nepal Research Center (JNRC) **9**: 101 ~ 160.

Kuhle, M. 1994a. Present and Pleistocene Glaciation on the North-Western Margin of Tibet between the Karakorum Main Ridge and the Tarim Basin Supporting the Evidence of a Pleistocene Inland Glaciation in Tibet. In: GeoJournal 33 (2/3), Tibet and High Asia, Results of the Sino-German and Russian-German Joint Expeditions (III). Kuhle, M. ed.); Kluwer, Dordrecht/ Boston/ London: 133 ~ 272.

Kuhle, M. 1994b. New Findings on the Ice-cover between Issyk-Kul and K2 (Tian Shan, Karakorum) during the Last Glaciation. In: Zheng Du, Zhang Qingsong, Pan Yusheng (eds.. Proceedings of the International Symposium on the Karakorum and Kunlun Mountains (ISKKM), Kashi, China, June 1992. China Meteorological Press, Beijing: 185 ~ 194.

Kuhle, M. 1994c. New Findings on the Glaciation in High Asia: Results of the Expeditions 1989, 1992, 1993 to Central Tibet and the Western Karakorum and Himalaya Mountains. International Symposium and Field Workshop on Glacial Deposits in Monsoon Asia, Lanzhou, China: 13.

Kuhle, M., Kleindienst-Andreé, D. 1994. Glacio-geomorphological Expedition to the Karakorum North Slopes 1986. Glazial-geomorphologische Expedition in die Karakorum-Nordseite 1986.) Filmton-Farbfilm 16mm, Dauer

88min, produziert im Institut für den wissenschaftlichen Film (IWF); Film: V 2520-C 1856, Göttingen (English and German version).
Kuhle, M. 1995a. Glacial Isostatic Uplift of Tibet as a Consequence of a Former Ice Sheet. In: GeoJournal 37 (4); Kluwer, Dordrecht/ Boston/ London: 431 ~ 449.
Kuhle, M. 1995b. New Findings on the Former Glaciation of Russian Tian Shan (Kirgizia) and Eastern Sajan Mountains in South Sibiria and its Climatic Implication. In: Global Changes and Geography, The IGU Conference Moscow, Russia, August 14.-18., 1995, Moscow: 193.
Kuhle, M. 1995c. New Results concerning the Ice Age Glaciation in High Asia, in particular the Ice Sheet Glaciation of Tibet - Findings of the Expeditions 1991-1995. In: Terra Nostra, Schriften der Alfred-Wegener-Stiftung 2, International Union for Quaternary Research XIV, International Congress, Berlin: 149.
Kuhle, M. 1996a. Rekonstruktion der maximalen eiszeitlichen Gletscherbedeckung im Nanga Parbat Massiv (35°05'-40°N/74°20'-75°E). In: Beiträge und Materialien zur Regionalen Geographie 8, Forschung am Nanga Parbat. Geschichte und Ergebnisse. Kick, W. ed.); Geographisches Institut der T.U. Berlin: 135 ~ 156.
Kuhle, M. 1996b. Die Entstehung von Eiszeiten als Folge der Hebung eines subtropischen Hochlandes über die Schneegrenze - dargestellt am Beispiel Tibets. In: Der Aufschluss **47** (4. 145 ~ 164.
Kuhle, M. 1996c. Glazial-geomorphologische Expedition in die Karakorum-Nordseite 1986. In: Publikationen zu wissenschaftlichen Filmen des Institutes für den Wissenschaftlichen Film (IWF) Technische Wissenschaft/ Naturwissenschaft 12, Film C 1856; Göttingen: 185 ~ 256.
Kuhle, M. 1997a. New Findings concerning the Ice Age (Last Glacial Maximum) Glacier Cover of the East-Pamir, of the Nanga Parbat up to the Central Himalaya and of Tibet, as well as the Age of the Tibetan Inland Ice. In: GeoJournal 42 (2-3), Tibet and High Asia. Results of Investigations into High Mountain Geomorphology, Paleo- Glaciology and Climatology of the Pleistocene (Ice Age Research) IV. Kuhle, M. ed.); Kluwer, Dordrecht/ Boston/ London: 87 ~ 257.
Kuhle, M. 1997b. Rekonstruktion der maximalen eiszeitlichen Gletscherbedeckung im Ost-Pamir. In: Göttinger Geographische Abhandlungen 100, Geographie in der Grundlagenforschung und als angewandte Wissenschaft. Göttinger Akzente. Güßefeldt, J., Spönemann, J. eds.. 63 ~ 78.
Kuhle, M. 1997c. Periglacial Keyforms and Indicators of Permafrost and their Relationships with Ice Age Glacier Surfaces in Asia. In: Frozen Ground, International Permafrost Association 21: 11.
Kuhle, M. 1997d. The Ice-Age Glaciation of West-Tibet between Karakorum and Tarim Basin and its Impact on the Global Energy Budget. In: Shams, F.A. ed.. Colloquium on Geology and the Human Life 4.-6.01.1997, Lahore. Pakistan Academy of Geological Science, Lahore: 53 ~ 54.
Kuhle, M., Kuhle, S. 1997a. Der quartäre Klimawandel - System oder geschichtliches Ereignis? Überlegungen zur geographischen Methode am Beispiel von Eiszeittheorien. In: Erdkunde 51: 114 ~ 130.
Kuhle, M., Grosswald, M.G., Dyurgerov, M.B. 1997b. Quaternary Glaciation in North-Western High-Asia. In: Data of Glaciological Studies 81 (Proceedings of the International Symposium "Seasonal and Longterm Fluctuations of Nival and Glacial Processes in Mountains", Tashkent Symposium 12.-19.09.1993. 70 ~ 79.
Kuhle, M. 1998a. Reconstruction of the 2.4 Million qkm Late Pleistocene Ice Sheet on the Tibetan Plateau and its Impact on the Global Climate. In: Quaternary International **45/46**: 71 ~ 108 (Erratum: Vol. **47/48**:173 ~ 182 (1998) included).
Kuhle, M. 1998b. New Findings on the Inland Glaciation of Tibet from South and Central West Tibet with Evidences for its Importance as an Ice Age Trigger. In: Himalayan Geology 19 (2), The role of the Tibetan Plateau in forcing global climatic changes. Tandon, O.P. ed.. 3 ~ 22.
Kuhle, M. 1998c. The Ice Age Glaciation of East-Pamir (36°40'-39°10'N/74°40'-76°10'E). In: Stellrecht, I. ed.. Karakorum - Hindukush - Himalaya: Dynamics of Change. Culture Area Karakorum, Scientific Studies 4/1. Rüdiger Köppe Verlag, Köln: 29 ~ 47.
Kuhle, M. 1998d. Neue Befunde zur hochglazialen (riß- bis würmzeitlichen) Inlandvereisung Tibets aus Süd- bis Zentralwest-Tibet mit weiteren Hinweisen auf ihre global-klimatische Bedeutung als Eiszeitauslöser. In: Berliner Geographische Abhandlungen 63, Forschungsergebnisse zur Klimageschichte und Reliefentwicklung Nordafrikas und Asiens. Dieter Jäkel-Festschrift. Böse, M., Hofmann, J. eds.. 121 ~ 151.
Kuhle, M. 1998e. Landschaftsentwicklung extremen Hochgebirges - Karakorum und Kuenlun. Begleittext zum Film C 2017 "Karakorum". In: Publikationen zu wissenschaftlichen Filmen des Institutes für den Wissenschaftlichen Film (IWF) Technische Wissenschaft/Naturwissenschaft 13; Göttingen: 97 ~ 147.
Kuhle, M. 1998f. Neue Ergebnisse zur Eiszeitforschung Hochasiens in Zusammenschau mit den Untersuchungen der letzten 20 Jahre. In: Petermanns Geographische Mitteilungen 142 3/4. Pachur, H.-J., Wünnemann, B. eds.); Justus Perthes Verlag, Gotha: 219 ~ 226.
Kuhle, M. 1998g. The Mechanism of the Genesis of Ice Ages induced by the Uplift of the Tibetan Plateau. In: 1998 Annual Meeting of IGCP 415 Grand & Meetings of Working Groups 2 & 7, Manali and the Lahul Himalaya, Abstracts. Ed: Owen, L.) University of California, Riverside: 4.
Kuhle, M. 1998h. Die eiszeitliche Vergletscherung Tibets und einfassender Gebirge: Neue Daten, Befunde, Synthesen und Konsequenzen. International Geological Cooperation Project (IGCP) 415 in Potsdam am 08. und 09.05.1998; Abstract.
Kuhle, M., Meiners, S., Iturrizaga, L. 1998a. Glacier-induced Hazards as a Consequence of Glacigenic Mountain Landscapes, in Particular Glacier- and Moraine-dammed Lake Outbursts and Holocene Debris Production. In: Kalvoda, J., Rosenfeld, C.L. eds.. Geomorphological Hazards in High Mountain Areas; The GeoJournal Library. Kluwer Academic Publishers, The Netherlands: 63 ~ 96.
Kuhle, M., Kleindienst-Andreé, D. 1998b. Landscape Development in an extrem Montan Environment – Karakorum and Kunlun. Landschaftsentwicklung extremen Hochgebirges - Karakorum und Kuenlun.) Lichtton-Farbfilm C 2017 "Karakorum",Institut für den Wissenschaftlichen Film (IWF), 50 Min; Göttingen (German and English version).
Kuhle, M. 1999a. Reconstruction of an approximately complete Quaternary Tibetan Inland Glaciation between the Mt. Everest- and Cho Oyu Massifs and the Aksai Chin. - A new glaciogeomorphological southeast-northwest diagonal profile through Tibet and its consequences for the glacial isostasy and Ice Age cycle. In: GeoJournal 47 (1-2), (Results of Investigations into High Mountain Geomorphology, Paleo-Glaciology and Climatology of the Pleistocene), Tibet and High Asia (V). Kuhle, M. ed.); Kluwer, Dordrecht/ Boston/ London: 3 ~ 276.
Kuhle, M. 1999b. The Uplift of Tibet above the Snowline and its Complete Glaciation as Trigger of the Quaternary Ice Ages - A Hypothesis for the Ice Age Development. In: Geological Society of America (GSA) Publications **31**: 141.
Kuhle, M. 1999c. Maximum Ice Cover in High Asia during the Ice Age - Extent, Age and Palaeoclimatic Impact. In: Lee-Thorp, J., Clift, H. eds.. The Enviromental Backround to Homimid Evolution in Africa. XV International INQUA Congress 3-11 August 1999 Durban, South Africa. Book of Abstracts. INQUA, Durban, South Africa: 102 ~ 103 (SO9.5).
Kuhle, M. 1999d. New Findings Supporting the Pleistocene Ice Sheet on the Tibetan Plateau as a Trigger of the Quarternary Ice Age - A Hypothesis for Ice Age Development. In: Zheng Du (ed.. Proceedings on International Symposium on the

Qinghai-Tibet Plateau, 21-24.07.1998 Xining, Abstracts. Chinese Academy of Sciences, Xining, China: 69 ~ 70.
Kuhle, M. 1999e. Maximum ice cover in High Asia during the Ice Age - its extent, age and paleoclimatic impact. In: Terra Nostra, Schriften der Alfred-Wegener-Stiftung 99 (2), 14th Himalaya-Karakorum-Tibet Workshop, Kloster Ettal 24.-26. March 1999. Sobel, E., Appel, E., Strecker, M., Ratschbacher, L., Blisniuk, P. (eds.): 90 ~ 91.
Kuhle, M., Xu Daoming. 1999. INQUA Excursion 14 A: Quaternary glaciation and periglaciation in the Qinghai-Xizang (Tibetan) Plateau (excursion guide XIII INQUA, 1991, Beijing, China). In: Zheng Benxing, Shen Yongping (eds.): Problems on Quaternary Glaciation Research in the Qinghai-Tibetan Plateau. Contributions Collections of Research on Quaternary Glaciation and Environments in the Qinghai-Tibetan Plateau. Lanzhou Institute of Glaciology and Geocryology, Chinese Academy of Sciences, Lanzhou, China: 480 ~ 484.
Kuhle, M.; Schroeder, N. 2000. New Investigations and Results on the Maximum glaciation of the Kirgisen Shan and Tian Shan Plateau between Kokshaal Tau and Terskey Alatau. In: Pamir and Tian Shan. Contribution of the Quaternary History. International Workshop at the University of Bayreuth. Abstracts. Ed: Zech, W.) University Bayreuth, Bayreuth, 8.
Kuhle, M. 2000a. The Uplift of Tibet above the Snowline and its Complete Glaciation as Trigger of the Quaternary Ice Ages. - A Hypothesis for Ice Age Development. In: International Project on Paleolimnology and Late Cenozoic Climate IPPCCE 13. Shoji Horie (ed.): 36 ~ 59.
Kuhle, M. 2000b. New Findings Supporting the Pleistocene Ice Sheet on the Tibetan Plateau as a Trigger of the Quaternary Ice Ages - A Hypothesis for Ice Age Development. In: Zheng Du, Zhu Liping (eds.. Formation and Evolution, Enviromental Changes and Sustainable Development on the Tibetan Plateau - Proccedings of International Symposium on the Qinghai-Tibetan Plateau (Xining 1998). Academy Press, Xining, China: 96 ~ 115.
Kuhle, M. 2000c. Pleistocene Glaciations in the Himalayas and Tibet: New Findings from the Himalaya North Slopes to Central and Western Tibet. In: Marburger Geographische Schriften 135, Environmental Changes in High Asia. Proceedings of an International Symposium 29th of May to 1st of June 1997 under the auspices of the UNESCO. Miehe, G., Zhang Yili (eds.); Marburg/Lahn: 1-14 (ISBN 3-88353-062-X; ISSN 0341-9290).
Kuhle, M. 2000d. Ein reliefspezifisches Eiszeitentstehungsmodell auf der Basis hebungsbedingter Gletscherflächen und Albedozunahme sowie ihrer positiven klimatologischen Rückkopplung durch die Globalstrahlungsgeometrie. In: Klima zwischen Natur- und Geisteswissenschaften -Sustainability und Globaler Wandel-. Sektion E3 - "Simulation des Palaeoklimas") 5. Deutsche Klimatagung (5DKT) 2.-6. Oktober 2000, Hamburg. Programm und Abstracts. Zentrum fuer Meeres- und Klimaforschung Universitaet Hamburg, GKSS-Forschungszentrum Geesthacht, Hamburg: 46 ~ 48 (6.10.2000).
Kuhle, M. 2000e. The Glaciation of Tibet - Pacemaker of the Ice Ages. "Keynote speech" am 06.06.2000 auf dem "Symposium & field Workshop on Quaternary Glaciation in Monsoonal Asia" June 5-18, 2000, Chengdu China, der INQUA Commission on Glaciation und des International Geological Correlation Project 415; Abstract: 14.
Kuhle, M. 2000f. Late Pleistocene megaflood deposits as a product of numerous outbreaks of late glacial ice dammed lakes in Tibet and its bodering mountians. -A new concept for High Asia deduced from a very extended glaciation. In: Hydrological Consiquences Of Global Climate Changes Geologic And Historic Analogs Of Future Conditions; The Fourth International Meeting on Global Continental Palaehydrology GLOCOPH Moscow Aug. 2000; Conference Papers and Abstracts. (Ed: Georgiadi, A.): 160 ~ 161.(ISBN 5-89658-014-2).
Kuhle, M. 2001a. The Tibetan Ice Sheet, its Impact on the Paleomonsoon and Relation to the Earth's Orbital Variations.- In: Polarforschung **71** (1/2):1 ~ 13.
Kuhle, M. 2001b. The maximum Ice Age (LGM) glaciation of the Central- and South Karakorum: an investigation of the heights of its glacier levels and ice thicknesses as well as lowest prehistoric ice margin positions in the Hindukush, Himalaya and in East-Tibet on the Minya Konka-massif. In: GeoJournal 54 (2-4), 55 (1), Tibet and High Asia (VI. Glaciogeomorphology and Prehistoric Glaciation in the Karakorum and Himalaya. Kuhle, M. ed.); Kluwer Academic Publishers, Dordrecht/ Boston/:London: 109 ~ 396.
Kuhle, M. 2001c. The Glaciation of High Asia and its Causal Relation to the Onset of Ice Ages.- Die Erde. Vol. **132**: 339 ~ 359.
Kuhle, M. 2001d. Geomorphological Indicators of a Tibetan Ice Sheet during the LGM. Transactions, Japanese Geomorphological Union 22 (4, Fifth International Conference on Geomorphology of the International Association of Geomorphologists. Abstracts of Conference Papers. August 23-28 2001, Tokyo, Japan), C134.
Kuhle, M. 2001e. Reconstruction of Outlet Glacier Tongues of the Ice age South-Tibetan Ice Cover between Cho Oyu and Shisha Pangma as a further Proof of the Tibetan Inland Ice Sheet. Polarforschung **71** (3), 79 ~ 95.
Kuhle, M. 2002a. A relief-specific model of the ice age on the basis of uplift-controlled glacier areas in Tibet and the corresponding albedo increase as well as their positive climatological feedback by means of the global radiation geometry.- Climate Research. **20**: 1 ~ 7.
Kuhle, M. 2002b. Outlet glaciers of the Pleistocene (LGM) south Tibetian ice sheet between Cho Oyu and Shisha Pangma as potenial sources of former mega-floods. In: Flood and Megaflood Processes and Deposits: Recent and Ancient Examples. Special Publication of the International Association of Sedimentologists (IAS). Vol. 32. Eds: Martini,Peter; Baker,Victor R; Garzón,Guillermina) Blackwell Science, Oxford: 291 ~ 302.
Kuhle, M. 2002c. The Glaciation of Tibet – Pacemaker of the Ice Ages.- In: Desert and Alpine Environments. Advances in Geomorphology and Palaeoclimatology. Ed. Yang Xiaoping; China Ocean Press: 80 ~ 99.
Kuhle, M. 2002d. The geomorphological Development of the Karakorum Mountains during its Maximum Pleistocene Glaciation. Proceedings of International Conference on Mountain Environment and Development (October 15. - 19. 2002) Chengdu, VR-China Abstract Vol., 34 ~ 35.
Kuhle, M. 2002e. Die eiszeitliche Vergletscherung des Karakorum — Rekonstruktion der maximalen Gletscherausdehnung und Eismächtigkeiten. Terra Nostra (Schrift der Alfred-Wegner-Stiftung) 2002/6, DEUQUA-Tagung 2002 Potsdam/Berlin), 178 ~ 184.
Kuhle, M. 2003a. New geomorphological indicators of a former Tibetan ice sheet in the central and northeastern part of the high plateau. Zeitschrift für Geomorphologie N.F. Suppl.-Vol. **130**: 75 ~ 97. Berlin, Stuttgart)
Kuhle, M. 2003b. The former Glaciation of High- and Central Asia and its climatic Impact. Comments on the INQUA-COG-GLACIATION MAP 1:1 Mio. XVI INQUA Congress in Reno Nevada USA, July 23-30, 2003 Abstract Volume, 70.
Kuhle, M. 2004a. Glacial Geomorphology and Ice Ages in Tibet and surrounding mountains. Journal of Himalayan Sciences 2 (4, The 19th Himlalaya-Karakoram-Tibet Workshop, 10-12 July 2004 Niseko, Hokaido, Japan;, Eds: Arita, K.; Gautam, P.; Paudel, L.P.; Takada, Y.; Watanabe, T.), 186 ~ 187.
Kuhle, M. 2004b. The Pleistocene Glaciation in the Karakoram-Mountains: Reconstruction of Past Glacier Extensions and Ice Thicknesses. Journal of Mountain Science **1** (1), 3 ~ 17.

Kuhle, M. 2004c. The High Glacial (Last Ice Age and LGM) ice cover in High and Central Asia. Development in Quaternary Science 2c (Quaternary Glaciation - Extent and Chronology, Part III: South America, Asia, Africa, Australia, Antarctica, Eds: Ehlers, J.; Gibbard, P.L.), 175 ~ 199. Elsevier B.V., Amsterdam)

Kuhle, M. 2004d. New Results Concerning the Past Glaciation in Tibet, the Himalaya and the Karakoram. The 4th International Sypmosium on the Tibetan Plateau. August 4-7, **2004**: 104 ~ 105. Lhasa, China) .

Kuhle, M. 2004e. Past glacier (Würmian) ice thickness in the Karakoram and on the Deosai Plateau in the catchment area of the Indus river. Eiszeitalter und Gegenwart **54**: 95 ~ 123.

Kuhle, M. 2004f. The High Glacial (pre-LGM and LGM) glaciation of SE-Iranian mountains exemplified by Kuh-i-Jupar massif in The Zagros. Quarterly Geographical Journal of Territory **1** (2-3), 1 ~ 15, 1 ~ 8.

Kuhle, M. 2005a. The Maximum Ice Age Glaciation between Karakoram Main Ridge (K2) and the Tarim Basin and its Influence on the global Energy Balance. Journal of Mountain Science 2 (1), 5-22. Institute of Mountain Hazards and Environment, Chinese Academy of Science, Science Press, Beijing)

Kuhle, M. 2005b. The maximum Ice Age (Wurmian, Last Ice Age, LGM) Glaciation of the Himalaya - a glacialgeomorophological investigation of glacier trimlines, ice thicknesses, lowest former ice margin positions and snow-line depression in the Mt. Everest-Makalu-Cho Oyu Massifs (Khumbu- and Khumbakarna Himal). Joint Earth Science Meeting - Thrust Belts and Foreland Basins, Rueil-Malmaison, France, December, 14-16, 2005 Abstract Volume (Eds: Lacombe, O.; Lavé, J.; Roure, F.), 219 ~ 222.

Kuhle, M. 2005c. Glacial geomorphology and ice ages in Tibet and surrounding mountains. The Island Arc **14** (4), 346 ~ 367. Blackwell Publishing Asia Pty Ltd).

Kuhle, M. 2006a. The Reconstruction of Ice Age Glaciation of the Himalaya and High Asia by Quaternary Geological and Glaciogeomorphological Methods. Himalaya (Geological Aspects) **4** (Ed: Saklani, P.), 181 ~ 214. ISBN: 81-8904-14-3)

Kuhle, M. 2006b. Reconstruction of the Ice Age Glaciation in the Southern Slopes of Mt. Everest, Cho Oyu, Lhotse and Makalu (Himalaya) (Part1 u. Part 2). Journal of Mountain Science 3 Nr.2 u. Nr.3, 91 ~ 124 u. 191 ~ 227. Institute of Mountain Hazards and Environment, Chinese Academy of Science, Science Press, Beijing ISSN: 1672 ~ 6316)

Kuhle, M. 2006c. The Past Hunza Glacier in Connection with a Pleistocene Karakorum Ice Stream Network during the Last Ice Age (Würm). In: Karakoram in Transition - Culture, Development and Ecology in the Hunza Valley. Ed: Kreutzmann, H.) Saijid, A., Oxford University Press, Karachi, Pakistan, ISBN-13: 978-0-19-547210-3(N), 24 ~ 48.

Kukla, G., and An, Z.S. 1989. Loess stratigraphy in central China. *Palaeogeography, Palaeoclimatology, Palaeoecology* **72**, 203 ~ 225.

Landvik, J.Y., Bondevik, S., Elverhoi, A., Fjeldskaar, W., Mangerud, J., Salvigsen, O., Siegert, M.J., Svendsen, J.-I., and Vorren, T.O. 1998. The Last Glacial Maximum of Svalbard and the Barents Sea Area: Ice Sheet Extent and Configuration. *Quaternary Science Review* **17**, 43 ~ 75.

Liedtke, H. 1990. Stand und Aufgabe der Eiszeitforschung. In: Eiszeitforschung. Liedtke, H. Ed.. Wissenschaftliche Buchgesellschaft, Darmstadt.

Loczy, L.v. 1893. Die wissenschaftlichen Ergebnisse der Reise des Grafen Bla Széchéniy in Ostasien 1877-1880. 3 Abschnitt Geologie, **1**: 307 ~ 836.

Machatschek, F. 1913. Die Depression der eiszeitlichen Schneegrenze. Zeitschrift für Gletscherkunde, für Eiszeitforschung und Geschichte des Klimas **8**, 104 ~ 128.

Mangerud, J., Dokken, T., Hebbeln, D., Heggen, B., Ingolfsson, O., Landvik, J.Y., Mejdahl, V., Svendsen, J.I., and Vorren, T.O. 1998). Fluctuations of the Svalbard-Barents Sea Ice Sheet during the last 150 000 years. *Quaternary Science Reviews* **17**, 11 ~ 42.

Marsiat, I. 1994). Simulation of the northern hemisphere continental ice sheets over the last glacial-interglacial cycle: experiments with a latitude-longitude vertically integrated ice sheet model coupled to a zonally averaged climate model. *Palaeoclimates* **1**, 59 ~ 98.

Meiners, S. 1996. Zur Rezenten, Historischen und Postglazialen Vergletscherung an ausgewählten Beispielen des Tien Shan und des Nord-West-Karakorum. GeoAktuell **2**, 1 ~ 200.

Meiners, S. 1997. Historical to Postglacial glaciation and their differentiation from the Late Glacial period on examples of the Tian Shan and the N.W. Karakorum. GeoJournal 42 (2-3, Tibet and High Asia IV, Results of Investigations into High Mountain Geomorphology, Paleo-Glaciology and Climatology of the Pleistocene (Ice Age Research IV), Ed. Kuhle, M.), 259 ~ 302.

Meiners, S. 1998. Beobachtungen zur jüngeren Vergletscherungsgeschichte im Nordwestkarakorum und zentralen Tienschan. Petermanns Geographische Mitteilungen **142** (3/4), 227 ~ 232.

Meiners, S. 1999. The history of glaciation of the Rolwaling and Kangchenjunga Himalayas. GeoJournal 47 (1/2), Tibet and High Asia V, Ed. Kuhle, M.), 341 ~ 372.

Meiners, S. 2000. Preliminary Findings of Post- and Late Glacial Glaciation in Central and East Nepal. In: Zheng Du, Zhu Liping (eds.), Formation and Evolution, Environmental Changes and Sustainable Development on the Tibetian Plateau (Proceedings of International Symposium on the Qinghai-Tibetian Plateau, Xining 1998) Academy Press Xining, China, 122 ~ 133.

Meiners, S. 2001. The post to late glacial valley reconstruction on the Haramosh nort side (Mani, Baska, Phuparash valleys). GeoJournal 54 (nos. 2-4) 55 (no.1), Tibet and High Asia VI, Glaciogeomorphology and Prehistoric Glaciation in the Karakorum and Himalaya, Ed: Kuhle, M.), 429 ~ 450.

Nesje, A. and Dahl, S. 2001. Glaciers and Environmental Change., Key Issues in Environmental Change: 1 ~ 200

Norin, E. 1932). Quaternary climatic changes within the Tarim Basin. *Geographical Review* **22**, 591 ~ 598.

Odell, N.E. 1925) . Observations on the rocks and glaciers of Mount Everest. *Geographical Journal* **66**, 289 ~ 315.

Oestreich, K. 1906. Die Täler des nordwestlichen Himalaya.- Petermanns Geographische Mitteilungen, Ergänzungsband, **155**: 1 ~ 106.

Osmaston, H. A. 1999. Was there a great Tibetan Ice-Cap? A peer review of the field evidence and its interpretation questionnaire. In: Zheng Benxing, Shen Yongping (eds.. Problems on Quaternary Glaciation Research in the Qinghai-Tibetan Plateau. Contributions Collections of Research on Quaternary Glaciation and Environments in the Qinghai-Tibetan Plateau. Lanzhou Institute of Glaciology and Geocryology, Chinese Academy of Sciences, Lanzhou, China: 485 ~ 488.

Owen, L. A., Derbyshire, E., Fort, M. 1998. The Quaternary Glacial History of the Himalaya. Quaternary Proceedings No.6., Quaternary Research Association, London: 91 ~ 120.

Owen, L. A., Finkel, R. C., Caffee, M. W. 2002. A note on the extent of glaciation througout the Himalaya during the global Last Glacial Maximum. Quaternary Science Reviews **21**: 147 ~ 157.

Owen, L. A., D. J. Benn. 2005. Equilibrium-line altitudes of the Last Glacial Maximum for the Himalaya and Tibet: an assessment and evaluation of results. Quaternary International 138 ~ 139: 55 ~ 78.

Pachur, H.-J., and Wünnemann, B. 1995. Lake evolution in the Tengger Desert, northwestern China, during the last 40,000 years. *Quaternary Research* **44**, 171 ~ 180.

Penck, A.; Brückner, E. 1901-1909. Die Alpen im Eiszeitalter. Vol. 1 ~ 3.

Porter, S.C. 1970. Quaternary glacial record in Swat Kohistan, West Pakistan. Bull.Geol.Soc.Amer.**81**, 1421 ~ 1446

Prell, W.L., and Kutzbach, J.E. 1992). Sensitivity of the Indian monsoon to forcing parameters and implications for its evolution. *Nature* **360**, 647 ~ 652.

Prinz, G. 1927. Beiträge zur Glazilogie Zentralasiens.- Mitt. Jahrb. Kgl. Ungar. Geolog. Anst., 25, Budapest.

Quade, J., Cerling, T.E., and Bowman, J.R. 1989). Development of Asian monsoon revealed by marked ecological shift during the latest Miocene in northern Pakistan. *Nature* **342**, 163 ~ 166.

Rhodes, T.E., Gasse, F., Lin Ruifen, Fontes, J.Ch., Wei Keqin, Bertrand, P., Gibert, E., Melieres, F., Tucholka, P., Wang Zhixiang and Cheng Zhi Yuan (1996). A Late Pleistocene-Holocene lacustrine record from Lake Manas, Zunggar (Northern Xinjiang, Western China). *Palaeogeography, Palaeoclimatology, Palaeoecology* **120**, 105 ~ 118.

Rutter, N., and Ding, Z. 1993. Paleoclimates and monsoon variations interpreted from micromorphogenic features of the Baoji Paleosols, China. *Quaternary Science Reviews* **12**, 853 ~ 862.

Schroeder-Lanz, H. 1986. Beobachtungen zur rezenten und eiszeitlichen Vergletscherung am Kongurshan/ Pamir, Himmelssee/Tienshan und Koko Nor-Nanshan Qaidam. Ed.: M. Kuhle, Internat. Sympos. über Tibet und Hochasien, Okt.1985, Göttinger Geogr.Abh., H.**81**: 39 ~ 58

Schwerdtfeger, W. 1970. The climate of the Antarctic. World Survey of Climatology 14 (Climates of the polar regions, Ed: Orvig, S.), 253 ~ 355.

Seuffert, O. 1973. Die Laterite am Westsaum Südindiens als Klimazeugen. Zeitschrift für Geomorphologie Supplement **17**, 242 ~ 259.

Sharma, M. C., Owen, L. A. 1996. Quaternary Glacial History of NW Garhwal, Central Himalayas. Quaternary Science Reviews, Vol. 15, Elsevier Science Ltd.: 335 ~ 365

Shi Yafeng and Wang Jing-Tai. 1979. The Fluctuations of climate, glaciers and sea level since Late Pleistocene in China. Sea ice and climatic change level.

Shi Yafeng, Zheng Benxing and Li Shijie. 1992. Last glaciation and maximum glaciation in the Qinghai-Xizang (Tibet) Plateau: A controversy to M. Kuhle's ice sheet hypothesis.- Z. Geomorph. N. F., Suppl.-Bd. 84, Berlin, Stuttgart: 19 ~ 35.

Shi Yafeng (Scientific advisor), Li Binyuan, Li Jijun (Chief editors), Cui Zhijiu, Zheng Benxing, Zhang Qingsong, Wang Fubao, Zhou Shangzhe, Shi Zuhui, Jiao Keqin, Kang Jiancheng (Editors). 1991. Quaternary Glacial Distribution Map of Qinghai-Xizang (Tibet) Plateau, Scale 1:3,000,000, Science Press, Beijing.

Sirocko, F. 1989. Accumulation of eolian sediments in the northern Indian Ocean: record of the climatic history of Arabia and India. Berichte des Geologisch-Paläontologischen Instituts und Museums Kiel **27**, 1 ~ 114.

Sirocko, F. 1995. Abrupt change in monsoonal climate: evidence from the geochemical composition of Arabian Sea sediments. Habil-Schrift an der Universität Kiel, 216 S.

Tafel, A. 1914. "Meine Tibetreise. Eine Studienfahrt durch das nordwestliche China und durch die innere Mongolei in das östliche Tibet." 2 vol., Stuttgart, Berlin, Leipzig.

Tiedemann, R., Sarnthein, M., and Shackleton, N.J. 1994. Astronomic timescale for the Pliocene Atlantic O18 and dust flux records of Ocean Drilling Program site 659. Paleoceanography 9 (no 4), 619 ~ 638.

Trinkler, E. 1930. The ice age on the Tibetan Plateau and adjacent regions. *Geographical Journal* **75**, 225 ~ 232.

Van Campo, E., and Gasse, F. 1993. Pollen- and diatom-inferred climatic and hydrological changes in Sumxi Co Basin (Western Tibet) since 13,000 yr B.P.. *Quaternary Research* **39**, 300 ~ 313.

Verbitsky, M.Y., and Oglesby, R.J. 1992. The effect of atmospheric carbon dioxide concentration on continental glaciation of the northern hemisphere. *Journal of Geophysical Research* **97** D5, 5895 ~ 5909.

Wagner M. 2005. Geomorphological and pedological investigations on the glacial history of the Kali Gandaki (Nepal Himalaya). *GeoJournal* vol. 63 nos. 1-4 (Kuhle M. ed), Tibet and High Asia (VII), Glaciogeomorphology and former Glaciation in the Himalaya and Karakorum. 91 ~ 113.

Wagner, M. 2007. Zur pedologischen Relativdatierung glazialgeomorphologischer Befunde aus dem Dhaulagiri- und Annapurna Himalaja im Einzugsgebiet des Kali Gandaki (Zentral-Nepal). Dissertation, Universität Göttingen, unpublished: 1 ~ 323.

Weng Wen-Po & Lee, T.S. 1946. A Preliminary Study on the Quaternary Glaciation of the Nanshan. Bull. Geol. Soc. China **26**, 163 ~ 171.

Wiche, K. 1958. Die österreischische Karakorum-Expedition 1958. Mitt. Geogr. Ges. Wien **100**, 280 ~ 294.

Wünnemann, B., Pachur, H.-J., Li Jijun, Zhang Hucai. 1998. Chronologie der pleistozänen und holozänen Seespiegelschwankungen des Gaxun Nur/Sogo Nur und Baijian Hu, Innere Mongolei, Nordwestchina. *Petermanns Geograph. Mitt.* **142** (no 3+4), 191 ~ 206.

Xiao, J., Porter, S.C., An, Z., Kumai, H., Yoshikawa, S. 1995. Grain size of quartz as an indicator of winter monsoon strength on the loess plateau of central China during the last 130,000 yr. *Quaternary Research* **43**, 22 ~ 29.

Xu Daoming & Shen Yongping. 1995. On Ancient Ice-Sheet and Ice Age in the Tibetan Plateau. Journal of Glaciology and Geocryology Vol.17 No.3 Sept. 1995, 17 p (in Chinese, Abstract in English)

Zabirov, R.D. 1955a. Oledenenie gornogo massiva Muz-Kol. Isv.vsesoy.Geogr. Obschtsch **87**, 325 ~ 334.

Zabirov, R.D. 1955b. Oledenenie Pamira.

Zheng Benxing & Shi Yafeng. 1976. Quaternary Glaciation on the Mount Qomolongma area. In: Report on the Scientific Expedition (1966-1968) in the Mount Qomolongma area, Quaternary Geology. Science Press, Beijing, 30 ~ 60.

Zheng Benxing & Li Jijun. 1981. Quaternary Glaciation of the Qinghai-Xizang Plateau. Geological and Ecological studies of the Qinghai-Xizang Plateau. Proceedings of Symposium on Qinghai-Xizang (Tibet) Plateau (Beijing, China) **2**: 1631 ~ 1640, Beijing, New York.

Zheng Benxing (1988. Quaternary Glaciation of Mt. Qomolangma-Xixabangma Region. In: GeoJournal 17 (4), Tibet and High-Asia, Results of the Sino-German Joint Expeditions (I). Kuhle, M., Wang Wenjing (eds.); Kluwer, Dordrecht/Boston/London: 525 ~ 543.

Zheng Benxing & Rutter, N (1998. On the Problem of Quaternary Glaciations, and the Extent and Patterns of Pleistocene Ice Cover in the Qinghai-Xizang (Tibet) Plateau. Quaternary International. Vol. 45/46 pp. 109-122, INQUA/Elsevier Science Ltd. Great Britain.

Zheng Benxing & Jiao Keqin. 1999. Excursion Guidebook XI: Quaternary Glaciations and Periglaciations in the Qinghai-Xizang (Tibetan) Plateau (XIII INQUA, 1991, Beijing, China). In: Zheng Benxing & Shen Yongping (eds.): Problems on Quaternary Glaciation Research in the Qinghai-Tibetan Plateau. Contributions Collections of Research on Quaternary Glaciation and Environments in the Qinghai-Tibetan Plateau. Lanzhou Institute of Glaciology and Geocryology, Chinese Academy of Sciences, Lanzhou, China: 426 ~ 479.

Zheng Benxing. 1999. Did a large ice sheet really occur on the Qinghai-Xizang Plateau? In: Zheng Benxing & Shen Yongping (eds.. Problems on Quaternary Glaciation Research in the Qinghai-Tibetan Plateau. Contributions Collections of Research on Quaternary Glaciation and Environments in the Qinghai-Tibetan Plateau. Lanzhou Institute of Glaciology and Geocryology, Chinese Academy of Sciences, Lanzhou, China: 276 ~ 284.

Zech, W., Bäumler, R.; Savoskul, O.; Anatoli, N.; Petrov, M. 1996. Bodengeographische Beobachtungen zur pleistozänen und holozänen Vergletscherung des Westlichen Tienshan (Usbekistan). Eiszeitalter und Gegenwart **46**, 144 ~ 151.

Zech, W., Madhikarmi, D., Gerl, T., Beck E. 2001. Rekonstruktion der spätglazialen und holozänen Vergletscherung des Annapurna III-Nordgletschers unter besonderer Berücksichtigung der Böden als Indikatoren für Klimaschwankungen. Zeitschrift f. Gletscherkunde u. Glazialgeologie **37** (2), 141 ~ 158.

Zech, W., Glaser, B., Abramowski, U., Dittmar, C., Kubik, P.W. 2003. Reconstruction of the Late Quaternary Glaciation of the Macha Khola valley (Gorkha Himal, Nepal) using relative and absolute (14-C, 10-Be, dendrochronology) dating techniques. Quaternary Science Reviews **22**, 2253 ~ 2265