

LANDSCAPE DEGRADATION AND DESERTIFICATION IN THE MU US SHAMO,
INNER MONGOLIA – AN ECOLOGICAL AND CLIMATIC PROBLEM
SINCE HISTORICAL TIMES ?

With 10 figures and 3 photos

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Zusammenfassung: Landschaftsdegradation und Desertifikation in der Mu Us Shamo, Innere Mongolei – ein ökologisches und klimatisches Problem seit historischer Zeit?

In der Mu Us Shamo verbreitet auftretende mobile Dünen- und Sandfelder stehen im Gegensatz zu den dort aktuell vorherrschenden semi-ariden Klimabedingungen. Es handelt sich meist um Dünen, deren ursprüngliche Bildung in das letzte Hochglazial datiert wird und die durch eine seit ca. 2.300 Jahren verstärkt stattfindende unangepasste anthropogene Nutzung remobilisiert wurden. Phasen verstärkter Degradation und Desertifikation traten nach den bisher vorliegenden Befunden v. a. gegen Ende der Westlichen Han-Dynastie, der Tang-Dynastie, Qing-Dynastie sowie im Zeitraum 1911–1980 auf und sind eng mit Zeiten verstärkter Migration han-chinesischer Ackerbauern in das traditionell von zentralasiatischen Nomadenvölkern besiedelte Ordos-Plateau verknüpft. Rückzugs- bzw. Stagnationsphasen der han-chinesischen Kolonisierung sowie Zeiträume verstärkter Sandmobilität korrelieren nach den bisherigen Kenntnissen und Befunden häufig mit Zeiträumen verstärkter Dürrehäufigkeit bzw. trocken-kalten Klimaphasen in N-China. Es ist davon auszugehen, dass klimatische Schwankungen sowohl die han-chinesische Besiedlung als auch die Remobilisierung der Sande und die Desertifikation in der Mu Us Shamo während der letzten 2.300 Jahre erheblich mitbeeinflusst haben.

Summary: Extensive sand sheets and dunes are the dominant landforms throughout the semi-arid Mu Us Shamo, but are not in equilibrium with the modern climate. Previous studies indicated that dune formation mainly occurred during the last glacial period. However, these dunes and sand sheets have been intensively reworked by human intervention during several periods of Chinese land cultivation within the past 2,300 years. Large scale migration into this fragile steppe ecosystem and non-sustainable cultivation mainly occurred during the Western Han, the Tang, and Qing Dynasty, as well as during the period 1911–1980, leading to a conversion of nomadic pastoral systems to intensified cropping, environmental deterioration and desertification. In addition to this human impact, decade-scale historical droughts and cool-dry periods, characterized by an increased near-surface wind activity, must also be considered. Migration of Han-Chinese farmers into the eastern semi-arid regions of northern China often took place during moderately humid and temperate periods of strengthened summer monsoon influence. In contrast, emigration mainly occurred during relatively cooler and drier episodes, when the Mongolian-Siberian high-pressure cell was displaced to the south and winter monsoon winds and droughts strengthened. It is suggested that climate shifts favourable for increased sand supply and eolian activity additionally may have formed a basis for the historical sand reworking and desertification processes in the southern Ordos Plateau.

1 Introduction

Degradation of natural landscapes caused by human impact is as old as mankind's use of these landscapes itself. Desertification – a special form of landscape degradation found in semi-arid to arid areas – is a complex combination of degradation processes of the vegetation, soils and the water budget (MENSCHING 1990), caused and accelerated by human impact. It leads to an intensification of natural droughts and results in an actual expansion of deserts (MENSCHING a. SEUFFERT 2001). Desertification is mainly seen in arid-semi-arid savannah and steppe areas. It is caused by inappropriate land use (e. g. over-grazing). Degradation of the vegetation cover also leads to changes in the morphodynamic system which, besides causing an

acceleration of areal and linear erosion, may then be followed by intensified deflation as well as increasing accumulation of sand and dune sheets.

In contrast to regions in Northern Africa or South America, where increasing desertification is mainly a result of inappropriate land use during the 20th century (e. g. PÖRTGE a. MENSCHING 1996; AKHTAR et al. 1997; GEORGEN et al. 1998), landscape degradation and desertification in NW-China have been a serious ecological problem since historical time (ZHU et al. 1986, 1988; SHENG 1987). An example of such a region heavily degraded and affected by desertification is the Mu Us Shamo at the Ordos Plateau (Fig. 1) with its mobile, semi-fixed as well as fixed sand and dune sheets. These dunes and sand sheets, mainly found at the south-east edge of the Mu Us Shamo (Shamo = sea of

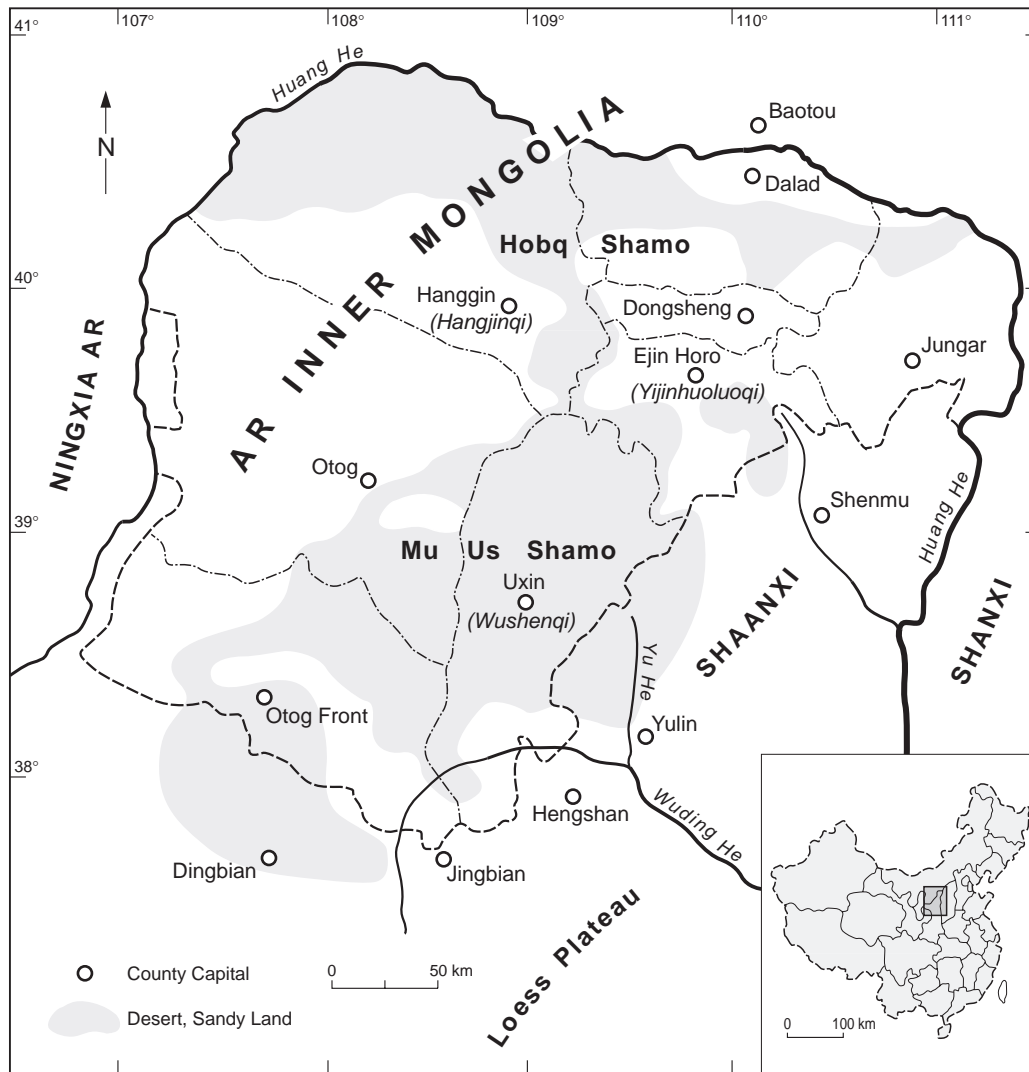


Fig. 1: Map of the Ordos Plateau and adjacent areas

Übersichtskarte des Ordos-Plateaus und angrenzender Gebiete

sands), seem to indicate a much more arid climate than actual climato-hydrological conditions in this semi-arid area suggest. Nevertheless, an increasing expansion of the sand and dune sheets, especially at the southern edge of the Mu Us Shamo (Photo 1) as well as their encroachment into the adjacent Loess Plateau can still be observed.

This mobility of the sands could be a result of an increasing aridity in NW-China over the last few centuries. However, this suggestion can be excluded once

the actual climatic and hydrological conditions in this region are taken into consideration (ZHU et al. 1986; SHENG 1987; ZHANG 1991; ZHOU et al. 2001). Within the last 130,000 years, sand dune formation at the desert – loess transition zone exclusively took place during the last glacial period, especially while oxygen isotopes 4 and 2 were predominant (SUN a. DING 1998). Radiocarbon dates from paleosols found in dunes (Photo 2) and yardangs yielded ages between 9,650 and 2,800 yrs. B.P., proving that the dunes and sand sheets



Photo 1: Mobile sand dunes around a lake at the south-eastern margin of the Mu Us Shamo, north of Yulin (Photo: ROST, 05.09.2000)

Mobile Sanddünen in der Umgebung eines Sees am SE-Rand der Mu Us Shamo, nördlich von Yulin



Photo 2: Holocene paleosol ($7,330 \pm 220$ yr B.P.; Hv 24230) in a dune, Uxin Banner (Photo: ROST, 09.09.2000)

Fossile Bodenbildung (7330 ± 220 B.P.; Hv 24230) in einer Düne im Uxin Banner

were generally fixed during the early and the middle Holocene (ZHANG et al. 1996; SUN et al. 1998; ZHOU et al. 2001; YANG et al. in press). Recent sand and dune movements in the study area are seen as a remobilisation of the eolic sediments, resulting of long-lasting human impact and increasing landscape degradation (ZHU et al. 1986, 1988; SUN et al. 1998; ZHU 1999).

Landscape degradation in the Mu Us Shamo has not been a continuous process. It has rather been a periodic phenomenon, coinciding with the Han-Chinese colonisation periods. The authors suggest that in this ecological transition area human relationships to natural environment and short-term climate shifts have always been in a complex state of flux. However, it is uncertain

to what extent such climatic shifts might have altered the course of the Han-Chinese land reclamation as well as the increased landscape degradation. As a preliminary research, this paper summarises the history of land use and degradation in the southern Ordos Plateau during the last 2,300 years, placed alongside climatic shifts mainly reconstructed from written accounts.

2 Research area

Mu Us Shamo ($37^{\circ}30' - 39^{\circ}30'N / 106^{\circ}10' - 110^{\circ}30'E$), which comprises about 32,000 km², is situated in the south of the Ordos Plateau. It is bordered by the great bend of the Huang He (Yellow River) to the north, west and east (see Fig. 1). The southern border is formed by the central Chinese Loess Plateau. On the administrative level, this region known as the Ih-Ju League, is part of the autonomous region of Inner Mongolia.

The southern border of the Mu Us Shamo basically follows the Wuding river and the Great Wall in the present province of Shaanxi. This part of the Great Wall was built in the 15th century. In this transitional zone between the semi-humid loess areas in the south and the semi-arid dry areas in the north, the wall represents a natural as well as a cultural border: Whereas mobile pastoral systems practised by central Asian nomads

have been dominant in the northern steppe areas since time immemorial, the loessic areas lying to the south have traditionally been the economic and cultural space of settled Han-Chinese farmers.

The study area is a typical semi-arid, wintery cold-dry steppe region. Its climate is influenced by the East-Asian monsoon circulation system. In winter, the Ordos Plateau is dominated by the Siberian-Mongolian high-pressure cell. The prevailing near-surface winds from the north and northwest transport dust and sand from the deserts and drylands in NW-China towards the study area. In summer, moist air masses from the southeast as well as extra-tropical cyclonic fronts and troughs reach the Ordos Plateau. In the Mu Us Shamo, mean annual temperatures lie between 6°C and 8°C. Mean annual precipitation rates decrease from the southeast (400 mm) to the northwest (200 mm). Nearly 70% of the annual precipitation is recorded between June and September. The region is generally characterised by a high variability in precipitation.

Strong alternation of “dry” and “humid” hazard years, during which precipitation amounts are either outstandingly higher or lower than the long-term mean annual precipitation rates, are characteristic of the region. Using precipitation records from the weather station Yijinhuoluoqi (Mongolian: Eijin Horo) as an example (Fig. 2), it can be seen that between 1959 and 1999 there were eleven years (26.9%) that displayed less

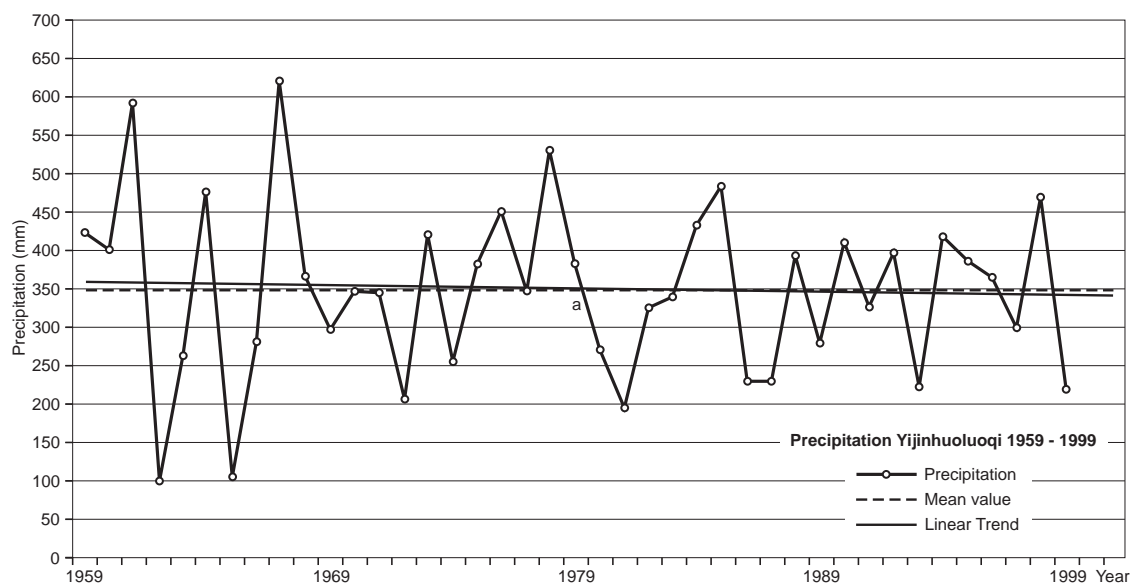


Fig. 2: Amount of mean annual precipitation (1959–1999), Yijinhuoluoqi climate recording station, north-eastern Mu Us Shamo

Niederschlagsverteilung (1959–1999) gemessen von der Station Yijinhuoluoqi am NE-Rand der Mu Us Shamo.

than 80% of the long-term mean annual precipitation rate. During ten years (24.3%) more than 120% of the long-term mean annual precipitation rate was recorded. Twenty years are recorded as “normal” years with 80% to 120% of the long-term mean annual precipitation rate. Thus about a half of the years were either “drought years” or “humid years”. Corresponding precipitation records from other weather stations in the research area (e. g. Wushenqi, Hangjinqi, Yulin) yield similar results.

According to the evaluation of multi-temporal satellite images and field observations 60 to 65% of all dunes in the Mu Us Shamo are mobile dunes. They are mostly barchan-like dunes reaching an average height of 5 to 10 m and sometimes a maximum height of 10 to 25 m. To the south the sands have scaled the Great Wall at several places and have reached up to 60 km into the adjacent Loess Plateau. It is striking that the actual distribution of mobile, semi-fixed and fixed sand dune sheets does not correspond with the natural landscape and climatic conditions. Whereas the drier areas situated in the north-west and in the centre of the Mu Us Shamo are only partly covered by mobile dunes and sand sheets, more extensive mobile dunes and sands cover the much more humid southern and eastern regions alongside the Great Wall. Due to recent climatic conditions, one would rather expect a kind of landscape ranging from semi-arid to semi-humid steppe, providing relatively favourable conditions for agricultural use. In actual fact, the southern and south-eastern regions of the Mu Us Shamo, which are subject to excessive sand encroachment, are mainly used for farming.

The density of cities founded in historical times (e. g. Yulin, Jinbian), the building of the Great Wall in the 15th century as well as the relatively great number of ruined cities and deserted settlements north of the Great Wall emphasise that the Mu Us Shamo was – at least periodically – inhabited and cultivated by Han-Chinese people even in historic times. According to WANG (1982), the now sand-covered ruins originating from the Han dynasty (206 BC–9 AD), are mainly found in the central and northern parts of the Mu Us Shamo, whereas those of the Tang (618–907 AD) and Qing (1644–1911 AD) dynasties are situated further south, near the Great Wall (Fig. 3). This southward shifts indicate several retreats of the Han-Chinese people from the Mu Us Shamo to its outer regions during the last 2,200 years. Increased landscape degradation in this region occurred periodically or reoccurred episodically and might be strongly related to the historical development of Han-Chinese colonisation of the Ordos Plateau.

3 *The Han-Chinese colonisation of the Ordos Plateau and the associated desertification in the Mu Us Shamo*

3.1 *The phase of colonisation of the Qin dynasty in the 3rd century BC*

The Ordos Plateau is not a farming region but rather a zone of pasture where traditional central Asian nomadic tribes live. The first larger, though also relatively short, expansion of farming Han-Chinese from the southern neighbouring loess areas into the Ordos Plateau occurred under the Qin. In 214 BC they moved the northern border of their kingdom in the area north of the Huang He river bend and the Hetao Plain (see Fig. 3). In order to secure the newly acquired areas against the nomadic Xiongnu, they began constructing the Great Wall and the north-south running Ordos Road. In addition, the installation of garrison bases and a massive forced resettlement of Han-Chinese people from the heavily populated regions of Central Shaanxi to the Ordos Plateau and the Hetao Plain were carried out (GERNET 1988; ZHU 1999). The temporary decline of the central state after 201 BC, military defeats and the recapture of the Ordos Plateau by the Xiongnu until 127/121 BC contributed to a general retreat of the Chinese to the loess areas.

3.2 *The colonisation phase during the Western Han dynasty (206 BC–24 AD)*

A second phase of expansion and colonisation took place during the Western Han dynasty with the re-conquest of the Ordos Plateau under the reign of Emperor Han Wudi (141–87 BC). Both of the initial colonisation phases were closely connected to a strong increase in population in the traditional Han-Chinese settlement areas. Between 127 BC and 2 AD, approx. 1.2–1.5 million people were resettled in the Ordos Plateau from the heavily populated central Chinese provinces (GERNET 1988; ZHU 1999). At this time agricultural technology only supported a relatively small population density and there was pressure to improve agricultural production and develop uncultivated land in China. The state resettlement policy freed up the heavily populated areas from their population surplus and allowed agricultural development of steppe areas in the Ordos Plateau by Chinese peasants. They were settled as so-called armed peasants in military/agricultural colonies and were instructed to supply the armies and ensure the security of newly-won steppe areas against the Xiongnu. Ruins of deserted settlements from this phase can be found in the north-west of the Mu Us Shamo, for example (see Fig. 3).

3.3 General phase of retreat between the 1st and 7th centuries AD

This second phase of colonisation came to a temporary end during the Eastern Han dynasty (25–220 AD) as well as the subsequent period of the Three Kingdoms (220–280). Already in the 1st century, a general retreat of the Han-Chinese colonists began from the northern and north-western margin areas to the core Chinese land. The number of inhabitants of the Loess Plateau also fell back from ca. 6.8 million (2 AD) to 1.9 million (280 AD) (ZHU 1999). The period following the second half of the 2nd century was characterised by an agricultural crisis, famines, peasant revolts (e. g. the “Yellow Turbans”) and foreign-sino tribes, increasing political and economic instability as well as the fragmentation of the kingdom.

At the beginning of the 4th century, droughts, famines and civil war triggered off the exodus of over 1 million Chinese to south China (GERNET 1988). At the same time, the steppe peoples already resident in North China began to form their own (“barbarian”) kingdoms which continued to exist until the 6th century. So the southern Xiongnu founded the Xia kingdom (407–431) on the southern margin of the Mu Us Shamo and established their temporary capital, Tongwan (37°59′

48′N/ 108°51′08′E), on the north bank of the Wuding river. According to historical sources (see ZHU et al. 1986; HONG 1999; ZHU 1999), Tongwan (Photo 3), nowadays surrounded by a 10 km-wide area of sand and mobile dunes, is supposed to have been situated in a verdant area with plentiful water, where agriculture and pastoral farming were practised. SHENG (1987) doubts, however, that comparatively humid climatic conditions led to the foundation of the city. He rather gives strategic military reasons as the impetus for its establishment.

Re-mobilised dune fields and areas with excessive sand, above all in the north of the Mu Us Shamo, were referred to for the first time in documents from the Northern Wei dynasty (386–534) and the end of Tang dynasty (618–907) (see ZHU et al. 1986; ZHU 1999). After Tongwan was increasingly threatened by mobile dunes and the city wall was overblown by dunes at least twice in 822 and 998, the city was abandoned at the end of the 10th century on imperial command. According to SHENG (1987), the abandonment of Tongwan cannot be attributed to serious climatic changes in the region. Rather, the main reasons were the increasing degradation of the landscape in the city surroundings and strategic military considerations.

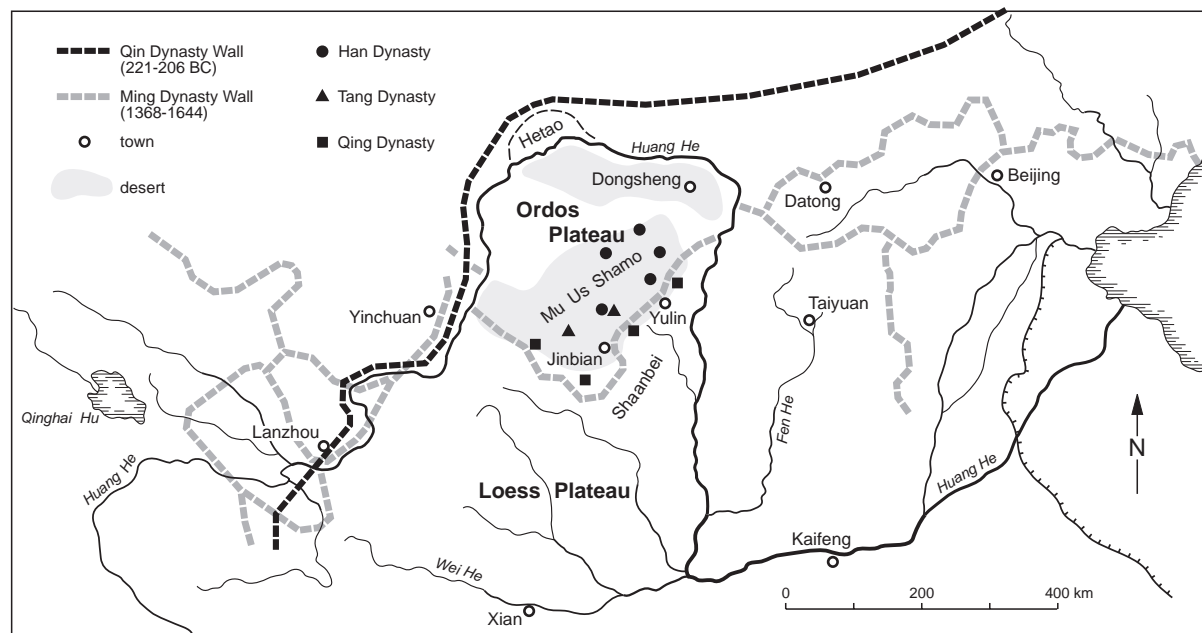


Fig. 3: Course of the Great Wall and distribution of ancient cities in the Ordos Plateau related to Han, Tang, and Qing Dynasty (Draft: RUFF)

Verlauf der Großen Mauer und Verteilung historischer Ruinenstädte aus unterschiedlichen Dynastien der chinesischen Geschichte im Ordos-Plateau

3.4 The 3rd phase of colonisation during the Tang dynasty in the 7th and 8th centuries

The degradation of the landscape in the southern Ordos Plateau has to be seen primarily in the context of a 3rd phase of expansion and colonisation towards the end of the first millennium. This expansion was connected with a renewed increase in population in central China. Following the repossession of the Ordos Plateau around 630 and the further massive expansion of the Chinese influence in central Asia during the Tang dynasty (618–907), there was a systematic extension of horse-breeding farmsteads with the creation of large state stud farms in the 7th and 8th centuries (ZHU et al. 1986). New settlers were recruited with exemptions from paying contemporary taxes. The foundation or rather re-foundation of numerous towns and settlements in the southern Mu Us Shamo was also connected to this.

The foundation of just such a settlement (in 820 AD) on the basis of an older preceding settlement was the now ruined town of Youzhou (37°42′32″N/108°19′36″E) near Chengchuan in the southern Otag Front Banner. While nomadic pasturing was practised in the region until the establishment of the city, in the following period there was extensive clearing and intensive agricultural use. According to ZHU (1999), this led to an increasing mobilisation of sand and finally the abandonment of the town, as was also occurring at the same time in the surroundings of Tongwan.

Among others, the increased felling of tree and shrub vegetation, the massive extraction of firewood and timber, inappropriate agricultural methods, as well as intensification of pastoral farming in this already ecologically sensitive landscape, were responsible for the first massive phase of intensified landscape degradation and desertification in the south of the Mu Us Shamo during the Tang colonisation phase (ZHU a. LIU 1983; ZHU et al. 1986). After the mid 8th century, increased occurrences of excessive sand, dune formation and droughts were mentioned in historical sources (see ZHU et al. 1986; ZHU 1999). As a result landscape degradation, increasing devastation due to military operations and the decline of traditional agricultural systems, resulting in a loss of influence of small-scale farmers, an extensive general retreat in population from the Ordos Plateau began again until the 10th century. The number of inhabitants in the neighbouring Loess Plateau also decreased from about 9.5 million at the beginning of the 7th century to ca. 5.3 million at the beginning of the 16th century (ZHU 1999).

3.5 Phase of stagnation and retreat during the 9th and 10th centuries and 1667

In addition, after the end of the 8th century, China's cultural and economic focus gradually shifted southward from the catchment area of the lower Huang He to the regions on the lower reaches of the Chiang Jiang (Yangtze River). During the Song dynasty (960–1279) and the Mongolian Yuan dynasty (1271–1368), there was apparently only negligible migration of Han-Chinese peasants into the Ordos Plateau. Only at the beginning of the Ming dynasty (1368–1644) did a short phase of Chinese expansion commence, the most important aspect of which was, however, the driving back of the steppe peoples. Already in the middle of the 15th century this expansion came to an end following military defeats against the Mongols in North China.

The following period is characterised by a strict Chinese defence and isolation policy, during which the extension of the Great (Ming) Wall occurred in North China between 1403/35 and 1480 (GERNET 1988). In the south and east of the Mu Us Shamo, the Wall ran parallel to today's 400 mm isohyeth, which represents the limit of dry farming. The possibility that this section of the Wall did not just served as a means of military defence but also as a wall of protection against the advancing mobile sands and dunes from the NW to the S/SE cannot be ruled out. It is worthy of note that today's ruined cities of the prior Han and Tang dynasties (e. g. Tongwan, Youzhou) are completely located outside the Wall. According to historical sources from the Ming dynasty, "all land with rich herbs [was] fenced inside the Great Wall" (ZHU et al. 1986, 59). Han-Chinese were not allowed to settle outside the Wall.

The construction of the Wall as a static border also had consequences for the desertification in the southern Mu Us Shamo. Numerous military garrisons were installed along the Wall, whose supply had to be guaranteed through a multitude of armed peasants in numerous military colonies. While settlement or farming was forbidden in a 25 to 30 km-wide military buffer zone outside the Wall, the land to the south of the Wall was used agriculturally along a wide front. The intensified agricultural land use, excessive extraction of firewood and timber as well as agricultural mismanagement encouraged further degradation of the landscape. In the following period, the Wall was constantly threatened by excessive sands. At the same time strategic military operations, such as the burning away of steppe vegetation "... beyond the Great Wall to stop the southward immigration of nomads in the winter season" (ZHU



Photo 3: Ancient city wall and tower ruins of Tongwan at the southern margin of the Mu Us Shamo (Photo: ROST, 22.09.2000)

Stadtmauer und Wehrturm der Ruinenstadt Tongwan am S-Rand der Mu Us Shamo

et al. 1986, 60), seriously impaired its natural regeneration. By the end of the 16th century Yulin, situated close to the Wall, was already surrounded by mobile dunes and the city walls were constantly threatened by the sands (SHENG 1987).

3.6 Phases of colonisation of the Qing dynasty (1644–1911) and the Republic of China (1911–1949)

During the Qing dynasty (1644–1911), the Great Wall lost its function, at least as a wall of military defence. After 1667, the military buffer zone north of the wall was once again opened up for general settlement and cultivation. Another increase in population was accompanied by an intensification of agriculture and pastoral farming in the south of the Mu Us Shamo, primarily along the Wuding river.

A relatively stable political and economic situation, innovations in agricultural technology and general prosperity were significant reasons for the demographic push in China during the 18th century. Between 1741 and 1812 the population in China increased from about 143 million to 360 million (GERNET 1988). The population in the Loess Plateau even rose from around 5.3 million at the end of the 16th century to over 31 million in 1820 (ZHU 1999). Inevitably, this led also to the further agricultural development of ecologically-sensitive dry areas, such as the Mu Us Shamo.

During the second-half of the 19th century and the first half of the 20th century, agriculture in the Mu Us Shamo was again critically endangered through excessive sand, deflation and salinisation of the soil. According to descriptions and photographs by CLAPP (1920), sand had blown over many parts of the Great Wall. Yulin was seriously threatened by mobile sand-dunes. The concentration of land ownership, the rise in numbers of tenant farmers, increasing tax burdens, non-conformist farming practices, as well as worsening decay of the irrigation system, led to destabilisation of the rural economy and heightened the susceptibility of the countryside to drought and an advancing desertification (ZHU et al. 1986; BETKE et al. 1987).

Nevertheless, a methodical development of the Ordos Plateau by means of a state-run “Land Reclamation Affairs Company” began at the end of the 19th century. The programme was executed in four phases, leading to the increasing conversion of pastoral land into agricultural cultivation (HONG 1999): The first phase (1877–1900) was mainly restricted to areas in the south of the Otog Front Banner as well as in the south and east of the Uxin Banners (Fig. 4). During the second phase (1901–1911), mainly areas in the north-east of the Ordos Plateau were developed. The third phase (1932–1948) primarily affected the northern margins of the Mu Us Shamo in the centre of the Ordos Plateau.

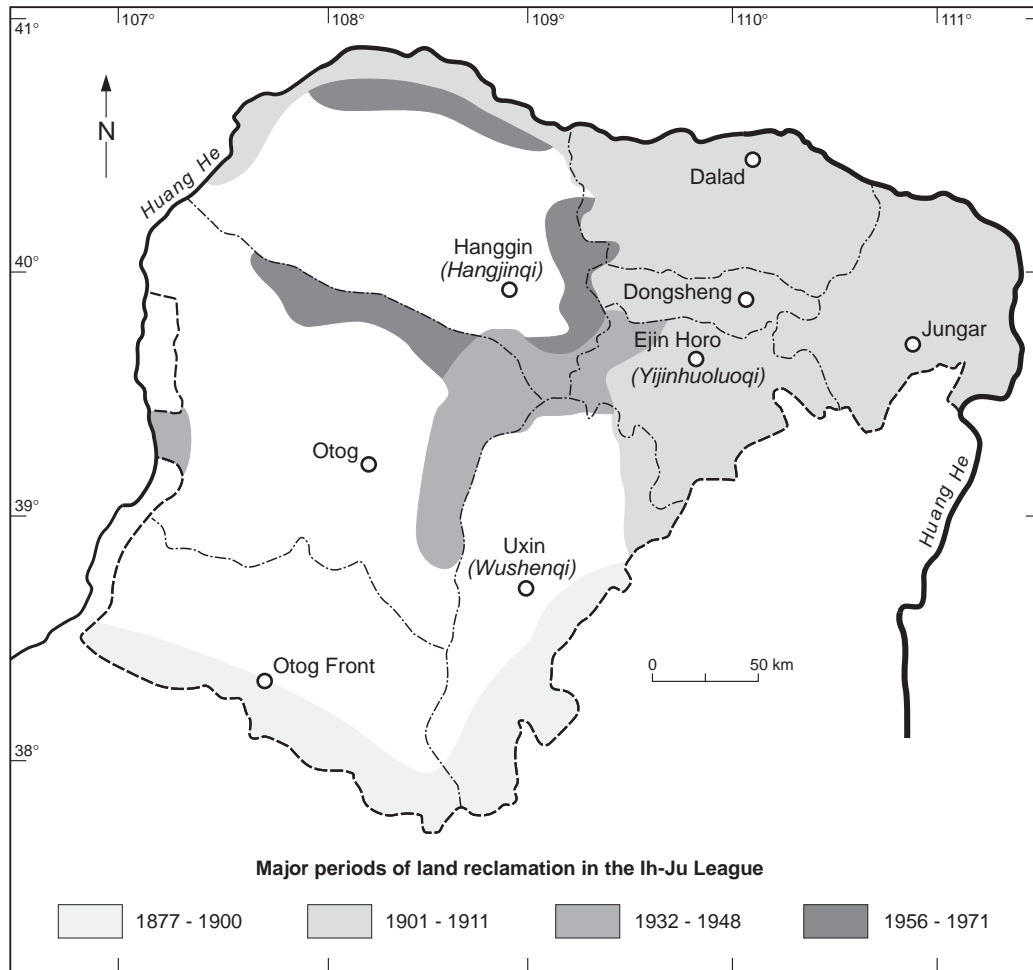


Fig. 4: Major periods of land reclamation in the Ordos Plateau between 1877 and 1971 (after: HONG 1999, changed)
Übersichtskarte der zwischen 1877 und 1971 neu erschlossenen Gebiete im Ordos-Plateau

3.7 Post-revolutionary phase of development after 1950

An overview of the progression and consequences of advancing degradation in the Ordos Plateau during the 20th century can be found in HONG (1950). Following the foundation of the People's Republic of China, the dry areas of the Ordos Plateau counted as reserve land in order to reduce population pressure in the central Chinese provinces and served as a place for new development of agricultural and pastoral areas. Between 1953–1979 the population of China rose from about 601 million to around 975 million. Different political campaigns also brought on a more extensive development of the Ordos Plateau. In the process, particularly areas in the northern Ordos Plateau, where average an-

nual precipitation is under 250 mm, were cultivated. The number of inhabitants in the Ih-Ju League increased from 513,600 (1954) to about 1.18 million (1989) (Fig. 5). In 1989, the proportion of Han-Chinese was 87.7% and the percentage of people employed in agriculture amounted to 82.7% (HONG 1999).

These most recent development campaigns were accompanied by massive expansion of irrigated areas as well as the foundation of large state farms. The establishment of people's communes, a massive expansion of agricultural land and livestock, failed political campaigns (e. g. "The Great Leap Forward" 1958–60, the Cultural Revolution 1966–76), as well as the intensified extraction of firewood and timber, precipitated further destruction of the countryside and a renewed

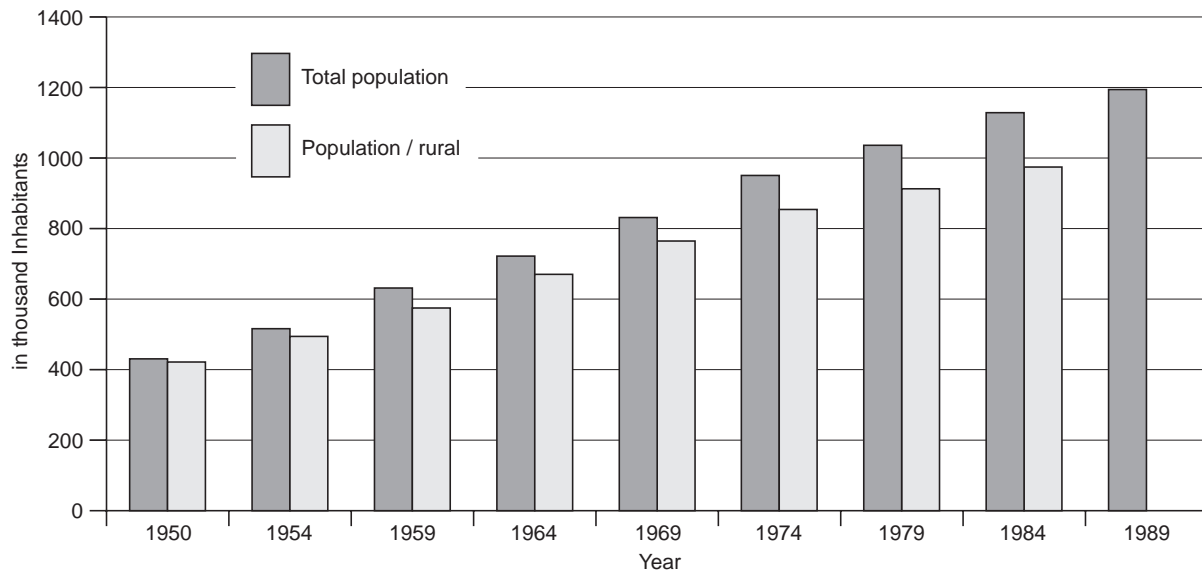


Fig. 5: Population growth in the Ih-Ju League (1950–1989), differentiated into total population growth and rural population growth (Data from HONG 1999)

Bevölkerungsentwicklung in der Ih-Ju League (Ordos-Plateau) differenziert nach Gesamtbevölkerung und ländlicher Bevölkerung zwischen 1950 und 1989

spreading of desertification in the Mu Us Shamo (WU a. CI 1998; HONG 1999), almost leading to disaster above all in the drought years of 1959–62.

Pastoral farming still accounts for the highest proportion of land use in terms of surface area in the Ih-Ju League, over 90% of which can be attributed to sheep and goat farming. However, in contrast to the historical times all Mongolian livestock owners in this region have today settled down and own pastures in the vicinity of their settlement. Alongside the expansion of cultivated areas, since 1950, there has been an increase in livestock numbers, which can be highly problematic during dry years since a decrease in precipitation in this semi-arid risk zone causes bio-mass production to sink.

According to HONG (1999), in 1949 in the Ih-Ju League the average amount of pasture available per sheep amounted to 3.6 ha, falling back to 1.1 ha in 1985. However, our own investigations show that in the year 2000 a typical household in Uxin Banner (Wushenqi) owned 120 to 150 ha pastureland and about 300 sheep and goats. In south-west Ejin Horo (Yijinhoulouqi) Banner, an eight-head Mongolian household with ca. 100 sheep/goats worked about 0.7 ha of agricultural land and around 30 ha pastures. This proves that in many places the area of pasture per sheep/goat currently amounts to only 0.3 to 0.5 ha.

In the Otog Banner (21,484 km²), the theoretical carrying capacity lies between 750,000 and 800,000 sheep/goats (HONG 1999). Despite this, by the late 1980s to early 1990s the actual figure was about 1 million in the banner. Our own research shows that similar conditions also apply in the adjacent banners of Uxin/Wushenqi (11,645 km²) and Ejin Horo/Yijinhoulouqi (ca. 6,900 km²). The official statistics for 1996 reveal that there are over 878,000 respectively more than 513,000 sheep/goats in these two banners (Fig. 6). In this way, over-pasturing certainly contributes to a considerable amount of the current degradation of the landscape and desertification in Mu Us Shamo.

4. Climatic factors contributing to historical degradation of the landscape

The extent of desertification is mainly dependent on underlying climatic conditions, in addition to destruction of vegetation and soil, the properties of relief and soil as well as the underlying rock type (MENSCHING 1990; MENSCHING a. SEUFFERT 2001). How far significant climatic shifts have influenced migration of Han-Chinese into and out of the Ordos Plateau, as well as periods of increased landscape degradation and deser-

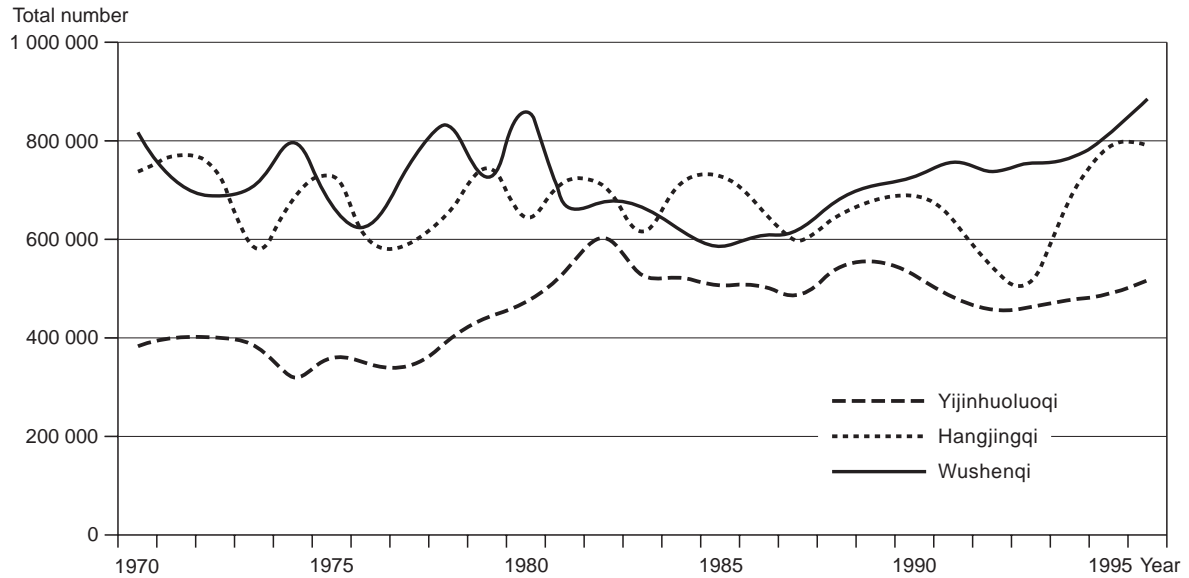


Fig. 6: Number of sheep and goats in the counties (banner) of Yijinhuoluqi, Hangjingqi, and Wushenqi between 1970 and 1995 (Data: Statistical Bureaus of the counties).

Anzahl der Schafe und Ziegen in den Bannern Yijinhuoluqi, Hangjingqi und Wushenqi (Mu Us Shamo) zwischen 1970 und 1995

tification, has not been considered in previous investigations. In the study area reconstructing climatic shifts of the past is extremely difficult, because reliable instrument records are only about a few decades old. However, proxy records from written sources and chronicles are available and invaluable for their remarks on unusual weather, although their usefulness in making comparisons is limited. The preliminary analysis of

historical sources reveals an alternation from comparatively cool-dry periods with relatively wet periods in North China during the last 2,000 years (e. g. LI a. QUAN 1987; SHENG 1987; ZHANG 1991).

According to ZHU (1999), there was a relatively high number of droughts from the 7th to 10th centuries, the 15th to 17th centuries as well as the 19th and 20th centuries in North Shaanxi (Shaanbei) bordering the

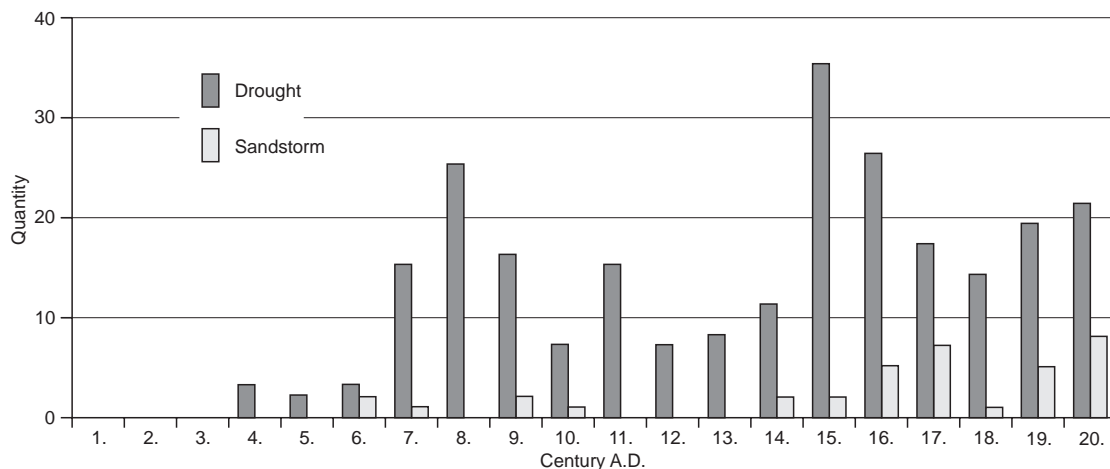


Fig. 7: Number of droughts and severe sandstorms in Shaanbei (North Shaanxi) during the past 2,000 years mentioned in various historical records (Data from ZHU 1999)

Anzahl der in historischen Quellen verzeichneten Dürren und großen Sandstürme während der vergangenen 2.000 Jahre in Shaanbei

Ordos Plateau to the south (Fig. 7). In addition, HSÜ (2000) mentions a large number of droughts, which occurred in the second half of the 2nd century. As millions of peasants then lived at subsistence level, the particularly serious droughts and famines in the years 176, 182 and 194 AD were at least a powerful motivator of the “Yellow Turban” peasant revolts. Furthermore a growing number of droughts and famines occurred between 220 and 260 as well as between 336 and 420 AD in North China (HSÜ 2000). They also coincide with the above-mentioned period of general retreat from the Ordos Plateau (see chapter 3.3), following both of the first colonisation phases of the Qin and the Han dynasty. These droughts can be correlated with a particularly cool-dry period at the beginning of the first Christian millennium, which is also reflected in a reconstruction of the average temperature of the last 5,000 years in N-China (Fig. 8). On the other hand, the previous colonisation periods during the Qin dynasty and the Western Han dynasty occurred during a considerably warmer and more humid phase.

The cool-dry period at the beginning of the first millennium AD can be explained by the occurrence of a climatic period in which the effect of the winter high-pressure cell over north China was strengthened and that of the summer monsoon weakened. A resulting increase in the barometric gradient would lead to an increase in near-surface circulation as well as an intensification of N/NW winds (see ROST 1998, 2000; SUN et al. 1998). This also explains why HSÜ (2000, 42) writes of a “Dust Bowl” in North China during the 4th and 5th centuries. Around this time an intensified loess accumulation also took place in the upper altitudes of the Wutai Mts., about 250 km east of the Mu Us Shamo (ROST 2001), providing another clear evidence of an increased dust transport over North China.

We cannot yet reconstruct the influence of this climatic shift on desertification processes in the study area in detail. But we suppose that not only the above-mentioned social and political disturbances, as well as the restrengthening of the steppe people, brought about the general retreat of the Han-Chinese from the Ordos Plateau and the following exodus from N-China at the beginning of the 4th century, but also a temporary deterioration in climatic conditions.

The cool-dry period ceased around the end of the 7th century, thus favouring another phase of expansion and colonisation in the Ordos Plateau and NW-China after 630 AD. Affected by landscape degradation and a further climate deterioration (see Fig. 8), this expansion during the Tang dynasty came to an end after the 9th/10th century with a further phase of retreat of the Chinese from these regions. According to historical sources mentioned by ZHU et al. (1986) and ZHU (1999), there was an increasing occurrence of excessive sandification and dune formation alongside frequent droughts since the middle of the 8th century. In the following there are numerous entries of unusually cold weather in the chronicles from the last years of the Yuan dynasty (1271–1368).

Once again a short phase of colonisation took place in the study area at the beginning of the 15th century. However, it was brought to a standstill when the Great (Ming) Wall was built in the second half of the 15th century. There were numerous famines between 1458 and 1521 (GERNET 1988) and an abnormally high number of droughts in N-China (Fig. 7). The last four decades of the Ming dynasty (1368–1643) and the first few years of the Qing dynasty (1644–1911) were among some of the coldest and driest epochs in Chinese history. Chronicles report several famines between 1618 and 1643 associated with a high number of droughts, famines

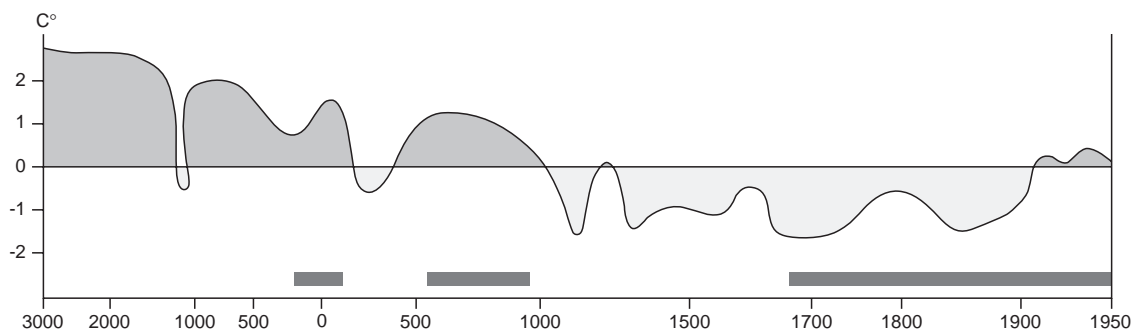


Fig. 8: Inferred average temperature variations in N-China for the last 5,000 years (after: ZHANG 1991, changed) and the three main periods of the historical Han-Chinese colonisation during the Qin/Han Dynasty, the Tang and the Qing Dynasty
Rekonstruktion des mittleren Temperaturverlaufs (Abweichung vom Mittelwert) der letzten 5.000 Jahre v. h. in N-China (nach: ZHANG 1991, verändert) und Zeitraum der drei Hauptkolonialisierungsphasen während der Qin-/Han-Dynastie, der Tang- und der Qing-Dynastie

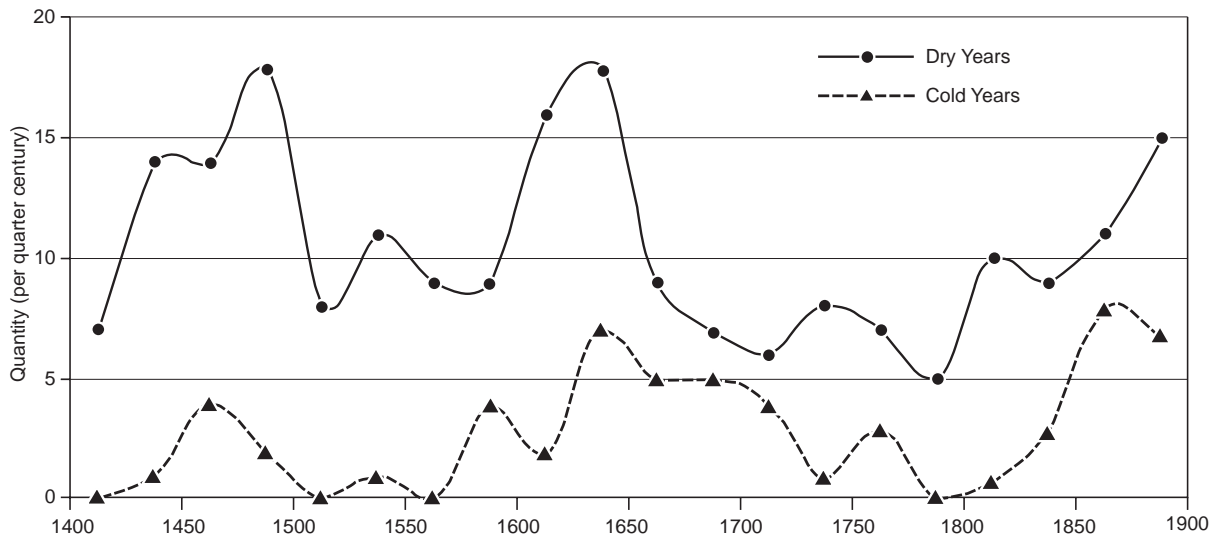


Fig. 9: Number of relative dry and unusual cold years in the Guanzhong Plain (1400–1900) mentioned in various historical records (Data from ZHU 1999)

Anzahl der in historischen Quellen aufgeführten relativ trockenen und der außergewöhnlich kalten Jahre in der Guanzhong-Ebene (südliches Lößplateau) zwischen 1400 und 1900

and social unrest (see GERNET 1988; ZHU 1999; HSÜ 2000). By the 1640's, even the Yangtze River Valley of the south suffered serious droughts. This time-period was at the beginning of the distinctive peak of the "Little Ice Age" during which there were numerous droughts in North China. The relatively cool and dry years cited in ZHU (1999) from 1400 to 1900 in the Guanzhong Plain at the southern margin of the Loess Plateau confirm at least that periods with a high number of dry years were often also those with increasingly occurring cold years (Fig. 9).

The most recent phases of colonisation in the Ordos Plateau must be seen above all in the context of the unprecedented demographic pushes in China which have occurred since the 18th century and the resulting pressure to secure food through the development of additional agricultural areas in the ecologically sensitive dry areas in NW-China. It is indisputable that the degradation of the landscape and the subsequent advance in desertification in the Mu Us Shamo between the end of the 19th century and about 1970/80 had reached its peak for the last 2,300 years (e. g. ZHU et al. 1983, 1986, 1988; HONG 1999).

The results of chronological analyses of available precipitation observations for the period 1970–1999 in the study area (Fig. 10) do not, however, provide proof of a recent climatic disposition towards degradation and desertification. Nevertheless, the high variability of precipitation in the period 1970–99, which manifests

itself in a statistical probability of falling below 200 mm p. a. of over 10% should also be taken into account especially in the north-west of the study area. When considered together with the overall climatic sensitivity of the area with regular dry periods and corresponding consequences for use potential, negative precipitation trends for the period 1970–99 cannot easily be identified, especially in the semi-arid western regions. In fact, there have hardly been any significant changes in precipitation trends and those changes noticeable have been positive rather than negative.

Hence, a climatically-determined aridification of the area during the period 1970–1999 can, to a large extent, be ruled out. The variability of precipitation for the periods 1951–1980 and 1961–1990 displays a generally extremely heterogeneous pattern of positive and negative trends which are seldom significant (BÖHNER 1996). Therefore, there are no other external microclimatic causes for the processes of degradation and desertification in the semi-arid to semi-humid central Chinese regions other than a general disposition towards variable climatic conditions. Even if one maintains that measuring precipitation rates for a given time and performing frequency analyses of its amount are required for a precise description of climatic disposition for instance, it should be recognised that there is, on the whole, a high probability that the negative development was due to inappropriate patterns of use.

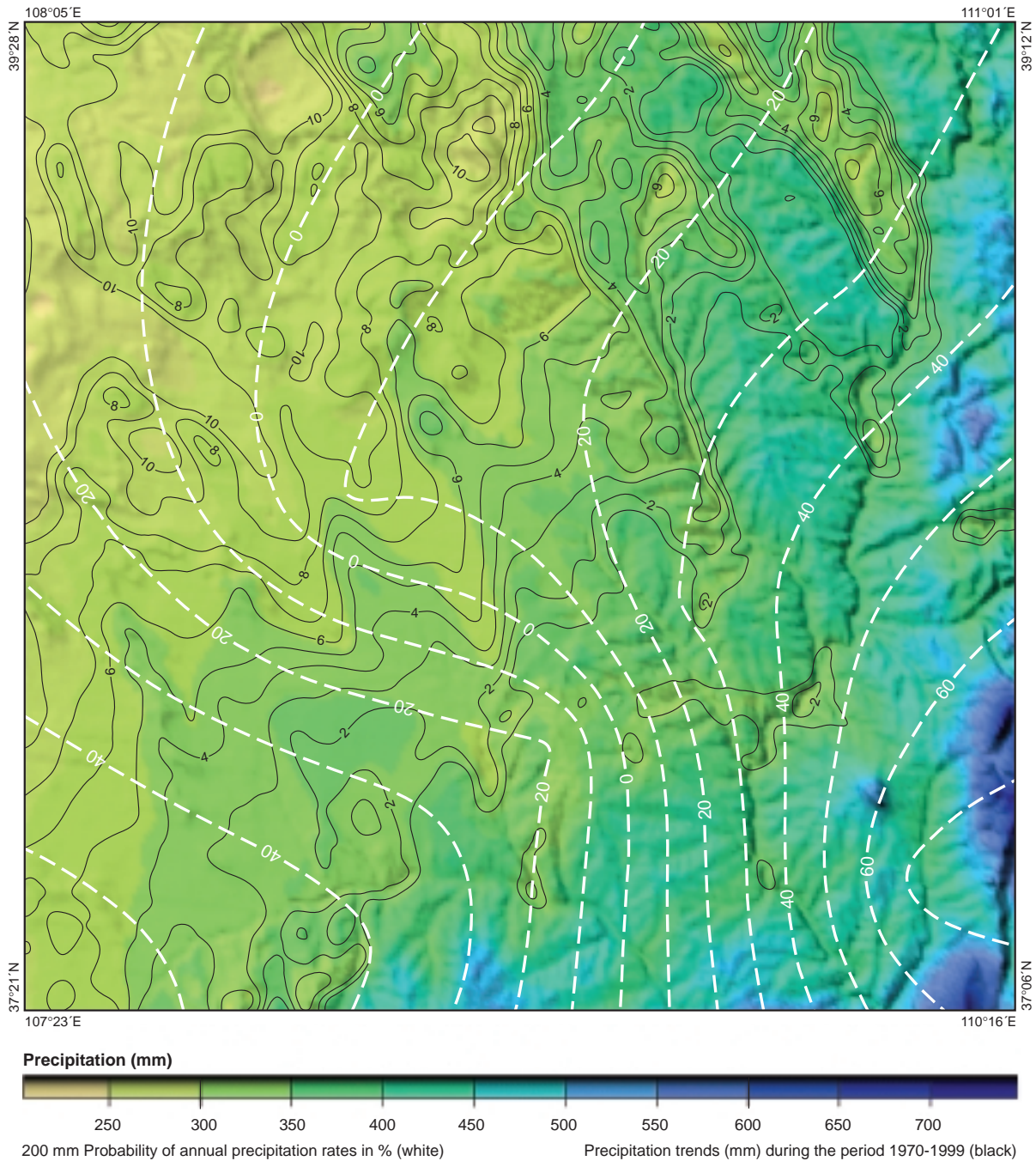


Fig. 10: Distribution of annual mean precipitation (in mm), statistical probability of annual precipitation rates less than 200 mm (white), precipitation trends (mm) in the SE-Ordos Plateau (Yulin county and Uxin bonner) during the period 1970–1990 (black)

Niederschlagsverteilung (Jahressummen in mm), statistische Unterschreitungswahrscheinlichkeiten von Jahressummen unter 200 mm in Prozent (weiß) und Niederschlagstrends (in mm) der Periode 1970–1990 (schwarz) im südöstlichen Ordos-Plateau

5. Conclusion

The southward shift and the mobility of sands and dunes in the Mu Us Shamo are not a result of an increasing aridity in NW-China, but rather the result of the increased human impact and non-sustainable land use practices during the last 2,000 to 2,300 years. Since then the natural steppe environment has been severely affected by an increase in human population, deforestation, shifting conversion of nomadic systems to intensified farming activity by frequently migrating Han-Chinese farmers, warfare and the drought-prone climate. In addition, these factors were amplified through natural variations in precipitation and climatic shifts.

Though the traditional nomadic pastoral system apparently ensures a dynamic adjustment to the specific ecological conditions, the agricultural land use practised by the Han-Chinese colonists could not react flexibly enough to the climatic fluctuations in the availability of resources. During so-called "hazard years" with low precipitation or rather comparatively dry periods, the intensification of unsuitable land use hindered the sufficient renewal of resources still available in the wet periods. This led to an intensifying degradation of the landscape and increasing desertification in the Mu Us Shamo.

One certainly cannot argue that only rapid climatic shifts have influenced the history of Han-Chinese land reclamation in the Ordos Plateau. Nor, however, can one content that such climatic shifts are something that can be totally ignored. It is rather plausible to suppose that environmental changes, droughts, sandstorms and famines were often accompanied by civil unrest and even retreats of the Han-Chinese colonists from the Ordos Plateau. At least this preliminary research gives references that during the past 2,300 years such phases of retreat often coincided with periods of drier and cooler climate as well as intensified eolian activity in N-China.

Previous studies of the quaternary climatic history of N-China verify that climatic oscillations and the intensification of eolian activity are closely connected to fluctuations in the intensity of monsoon circulation (e. g. DING et al. 1995; ROST 1998, 2001). While an increase in the influence of the (summer) monsoon results in comparatively humid and warm climate conditions as well as a decrease in eolian activity in the study area, an amplification of the influence of the winter high-pressure cell in comparatively cool-dry climatic periods causes a significant intensification of near-surface NNW-SSE winds and thereby increasing eolian sand and dust transport in N-China.

It is further suggested that climatic oscillations not only influenced migration of the Han-Chinese into the study area, but were also an important factor in the complex combination of the natural and human induced degradation processes that caused desertification and the expansion of the Mu Us Shamo within the last 2,000 to 2,300 years. Between 1949 and about 1980 the landscape degradation and desertification primarily "inherited" from the previous colonisation phases was further exacerbated through state settlement, economic and non-sustainable land use policies. Further interdisciplinary investigations, including the analysis of written sources and chronicles, should help to reconstruct the complex history of landscape degradation and desertification in the Mu Us Shamo and adjacent regions in greater detail.

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