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A RECONNAISSANCE OF A HIGH MOUNTAIN REGION

Final Report
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13. ABSTRACT In the summer of 1966, a team of investigators of the Arctic Institute, with financial support from the U.S. Army Research Office - Durham (ARO-D), made a reconnaissance in the St. Elias, Wrangell, and Chugach Mountains to search for areas that appeared to be analogous to the Himalaya from an operational viewpoint. An area between May Creek, Alaska, and the Alaska-Yukon border was found to present a variety of features strikingly comparable to those found in important areas of the Himalaya. Also, areas were found on the high slopes of Mt. Logan where human physiology research could be conducted at elevations of 11,000 ft, 16,000 ft, and above 18,000 ft. It is feasible to establish a project in the above region to provide opportunities for appropriate applied research, materiel testing and evaluation, and specialized training.

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THE ARCTIC INSTITUTE OF NORTH AMERICA

Abstract. A Reconnaissance of a High Mountain Region

In the summer of 1966, a team of investigators of the Arctic Institute, with financial support from the U. S. Army Research Office - Durham (ARO-D), made a reconnaissance in the St. Elias, Wrangell, and Chugach Mountains to search for areas that appeared to be analogous to the Himalaya from an operational viewpoint.

An area between May Creek, Alaska, and the Alaska-Yukon border was found to present a variety of features strikingly comparable to those found in important areas of the Himalaya. Also, areas were found on the high slopes of Mt. Logan where human physiology research could be conducted at elevations of 11,000 ft, 16,000 ft, and above 18,000 ft.

It is feasible to establish a project in the above region to provide opportunities for appropriate applied research, materiel testing and evaluation, and specialized training.

A RECONNAISSANCE OF A HIGH MOUNTAIN REGION

Background

The Arctic Institute of North America has conducted since 1961 a study of the environment of the high mountain region of the southwest Yukon Territory. The area under study has been the Icefield Ranges of the St. Elias Mountains and the Shakwak Valley, which lies to the east.

It has been postulated that within the St. Elias Mountains and the neighboring Wrangell and Chugach Mountains, regions could be identified that would be analogous in many ways to the Himalaya. In November 1965 the Arctic Institute requested financial support from the Chief of Research and Development, Department of the Army, to conduct a long-term comprehensive study of the environment of the high mountain glacial region of the St. Elias, Wrangell, and Chugach Mountains in Alaska and the Yukon Territory. The study was to be directed toward environmental problems that would affect the ability of man to live, to work, and to travel in a high mountain environment.

In May 1966 the Army Research Office - Durham (ARO-D), awarded Grant No. DA-ARO-D-31-124-G836 entitled "Study of High Mountain Glacial Regions" to the Arctic Institute of North America to conduct a preliminary reconnaissance during July of 1966. The objective of the 1966 program was to examine the area lying in the general vicinity of the Chitina River valley, Skolai Pass, Logan Glacier, Mt. Bona, and Mt. Logan to select areas that might serve as sites for research, materiel testing, and special training.

In July 1966 Robert C. Faylor, Barry C. Bishop, Walter A. Wood, and Philip P. Upton performed a reconnaissance in the St. Elias, Wrangell, and Chugach Mountains to determine whether some areas of those mountains are reasonably analogous to important areas of the Himalaya. It was recognized from the outset that the elevations of mountains, valleys, and passes in the Alaska-Yukon region would be much lower than similar features of the Himalaya. However, it was thought that the higher latitude of the study area would bring about climatic conditions (atmospheric pressure excepted) similar to those prevailing in the Himalaya, and thus permit useful analogies to be drawn.

Planning conferences were held prior to the field reconnaissance. At the several conferences, the following named individuals were contacted by the Principal Investigator:

Dr. Walter A. Wood, Director, Icefield Ranges Research Project, and President, American Geographical Society;
Dr. E. Lovell Becker, The New York Hospital Cornell Medical Center;
Mr. Barry C. Bishop, National Geographic Society;

Mr. Philip P. Upton, The Arctic Institute of North America;
Mr. Richard H. Ragle, The Arctic Institute of North America;
Dr. Melvin G. Marcus, Department of Geography, University of Michigan;
Dr. Terris Moore, Cambridge, Massachusetts;
Brigadier H. W. Love, Director, Montreal Office, The Arctic Institute of North America;
Dr. Carlos Monge, Department of Medicine, Universidad Peruans de Ciencias Medicas y Biologicas, Lima, Peru.

The major field objectives arising from discussions held at these conferences were as follows:

A. Identify general topographic similarities between the two mountain systems.
B. Identify physiographic details that appear to be similar in the two mountain systems.
C. Observe the climatic effect on surface features and identify possible analogies.
D. Observe the distribution of physical features and their interrelations, especially stream and valley morphology, the relationship of glaciers and snow line to passes, and the character and distribution of glaciers.
E. Make biogeographical observations of vegetation zones and their relations to the total mountain environment.
F. Evaluate logistic problems and their solutions in terms of future research, testing, and training programs.
G. Select sites as high as 18,000 ft at which studies in human physiology could be carried out and logistically supported.

In late June the St. Elias Mountains were examined by Mr. Bishop and Mr. Upton. During July, the Principal Investigator (Mr. Robert C. Faylor), Mr. Bishop, and Mr. Upton extended the reconnaissance into the Wrangell and Chugach Mountains. Dr. David F. Murray, plant ecologist; Dr. Marcus, climatologist; and Major W. J. B. Cocker, physiologist, participated in several phases of the work. In late July and early August Dr. Wood and Dr. Becker went over selected portions of the study area along with Major Cocker to consider possible areas for high elevation physiology studies.

The area covered by the reconnaissance is shown on Map 1 of this report.

Discussion of the Himalaya

From the Indus in the northwest to the Brahmaputra in the southeast, the Himalaya stretch in a broad continuous arc for nearly 1,600 miles along the northern fringe of the Indian subcontinent (see Map 2). The Hindu Kush and the Karakoram are at their western end. In the east they grade into the mountain systems of Southeast Asia. For the purposes of this report, the Karakoram Range and the ranges in Ladakh are included in the Himalaya,

although they are properly referred to as "Trans-Himalayan" ranges. Within the axial zone of the Great Himalaya stand the highest mountain massifs on earth. At its western end Nanga Parbat, 26,620 ft, towers above the Indus, while in the extreme east Namcha Barwa, 25,445 ft, rises above the Tsangpo Bend (the Tsangpo is known as the Brahmaputra when it flows south out of the Himalaya). Between these two mountain massifs are 31 peaks whose elevations are above 25,000 ft; 12 of these are over 26,000 ft.

The mountains have been a protection to the Indians, barring invaders attempting to come down from the north. In 1956 Communist China quietly breached the barrier in Ladakh. The invasion by the Chinese in 1962 came directly over the mountain range. Perhaps as simple and uncomplicated as the lives of the people who live in these mountains was the means by which the disputed Himalayan border between Tibet and neighboring countries was drawn. Representatives from China and Tibet met with the British delegate in Simla, India, in 1914. Sir Arthur McMahon, the chief British negotiator, drew a pencil line from one Himalayan peak to another on a map and suggested that the zigzag so formed be the border. All agreed though China later repudiated the boundary, which came to be known as the McMahon Line. Only since 1962 has the McMahon Line been demarcated on the ground. During the past 15 years several events have broken the seclusion of the remote, closed Himalayan mountain kingdoms such as Nepal, Sikkim, and Bhutan, whose rulers had actively discouraged foreign visitors. The Tibetan revolt against the Chinese Communists, the flight of the Dalai Lama, and Chinese territorial claims in the Himalaya have all had their effect.

Between the Gangetic plain on the south and the Tibetan Plateau on the north, three major physiographic divisions of the Himalaya are recognized.

The first is the long, low Siwalik Range. Youngest of all geologically, it is a comparatively low feature stretching from the Punjab to Assam - sometimes a single fold, sometimes a double fold- and often it has a broad plain or "dun" beyond it. A type example is at Dehra Dun, which is from 20 to 30 miles wide. In Hindu mythology it is considered the edge of the roof of Siva's abode in the Himalaya. It extends from the Indus with remarkable unity for over 1,500 miles to near the Brahmaputra and Assam with only one gap of about 200 miles from the Kosi River of Nepal to the Monic River of Bhutan. Here the fierce erosion of the summer monsoon has almost entirely destroyed it. Its greatest height above the Ganges is not more than 3,000 ft. It is often densely forested and is inhabited by the tiger, leopard, bear, rhinoceros, and other wild animals.

The second zone is known as the Lesser Himalaya. It is a complex, older zone averaging about 60 miles in width with the same general strike as the Siwaliks but one more contorted by uplift, which occasionally forces a change in direction. It is intensively carved by erosion. Great limestone ridges sometimes show their original alignment and parallelism, but more often they appear as spurs from a crystalline core of the higher ranges further to the north. In this zone whole hillsides may suffer from creep and

other mass erosion processes and disappear after a heavy rain. Often mountain paths and bridges are destroyed in this manner. Dense tropical forests cover the lower slopes of these mountains in the east while, with decreasing precipitation to the west, their place has been taken by magnificent corniferous forests, the outstanding example of which is the Deodar in Kashmir. It is on the outer fringe of the Lesser Himalaya, facing the Indian Plains, that the hill stations established during the British Raj are located. At altitudes from 5,000 to 7,000 ft are the famous towns of Murree, Dalhousie, Simla, Mussoorie, Ranikhet, Almora, Naini Tal, and Darjeeling. The average height of the Lesser Himalaya summits is approximately 15,000 ft, but many higher peaks are found, especially near the northern end of the range. In Nepal the Lesser Himalaya are divided into two units; an outer one with ranges such as Mahabharat Lekh south of the Nepal midlands, in which the Katmandu Valley is located, trending west-northwest to east-southeast; and an inner range generally trending north-northeast to south-southwest, north of the midlands of Nepal.

The third zone, the Great Himalaya, is the axis and crystalline core of the entire system. It is composed, fundamentally, of intruded granites and gneisses but is still occasionally capped with remnants of sedimentary rock. This is particularly true in the Mt. Everest massif in northeast Nepal. This core has been, and is being, carved into giant blocks or zones by the transverse tributary heads of the Ganges. The crests of the Great Himalaya rarely fall below 18,000 to 19,000 ft, except where the great river gorges have carved their way through at well-known passes. It is in this zone that the major mountains mentioned above are found.

The Himalaya ranges are classified into six divisions:

1. Punjab Himalaya;
2. Trans-Himalaya in Kashmir State, including the Karakoram and its associated ranges;
3. Kumaun Himalya;
4. Nepal Himalaya
   (a) Karnali;
   (b) Gandaki;
   (c) Kosi;
5. Sikkim Himalaya; and
6. Assam Himalaya

In all except the second and fifth of these divisions the three parallel zones of the range (the Siwalik Hills, the Lesser Himalaya, and the Great Himalaya) are present.

The three great rivers of south Asia - the Indus, the Ganges, and the Brahmaputra, along with their major tributaries - rise on the Tibetan Plateau to the north of the Himalaya. The waters to these drainage systems eventually reach either the Arabian Sea on the west or the Bay of Bengal on the east of

the Indian subcontinent. The western zones of the Himalaya are drained by the Indus and its tributaries, the Jhelum, Chenab, Ravi, Sutlej, and Beas Rivers. The northern flanks of the central divisions of the Himalaya drain either to the west or to the east via the Indus, Sutlej, and Tsangpo; the southern slopes all drain eastward into the Ganges system. The tributaries are DeJumna, Bhagarathi, Alaknanva, Kali, Seti, Karnali, Bheri, Gogra, Gandak, and Kosi Rivers. The eastern divisions of the Himalaya are drained by the Tista, Raidak, and Manas tributaries of the Brahmaputra.

The Himalaya are divided into three geologic zones that do not correspond to the physiographic zones previously stated. The first is the northern or Tibetan zone, in which fossiliferous beds of Paleozoic and Mesozoic age are largely developed (except in the northwest, no such rocks are known on the southern flanks). The second zone is the Himalayan zone and comprises most of the Lesser and Great Himalaya. It is composed chiefly of crystalline metamorphic rocks, mostly unfossiliferous sedimentary beds supposed to be of Paleozoic age. The southern zone is mostly the sub-Himalayan zone and consists entirely of Tertiary beds, especially Upper Tertiary. The oldest beds that have yielded fossils occur in Spiti Valley and belong to the Cambrian system. N. E. Odell (1925) did, however, find crinoid stems in the sedimentary beds high on Mt. Everest. The Himalaya grew southward in a series of stages during the Alpine Orogeny that started some 70 million years ago. A reverse fault was formed at the foot of the chain and upon this fault the beds were pushed forward over the beds deposited at their base in a series of nappes. This orogenic process formed a sub-Himalayan ridge in front of the main chain. This process was repeated several times, and the earthquakes of today in this region can be traced to the fault line. As in the Alps, and the Rocky Mountains of Alaska-Canada, crustal equilibrium has not yet been reached. It is hypothesized that the net effect in the Himalaya today is a rise of two millimeters a year.

The Himalaya are affected by, and also greatly affect, the general monsoon climate regimen of Southwest Asia. In most of the Himalaya approximately 80 percent of the precipitation occurs during the summer monsoon between the end of May and the beginning of October. The divisions of the Himalaya that receive the greatest precipitation are the Kumaun, Nepal, Sikkim, and Assam divisions. To the northwest, in the Punjab Himalaya and Trans-Himalayan ranges, the monsoon control diminishes and there is some climatic effect by disturbances moving from the Mediterranean. The wet season-dry season regimen is not so pronounced. Contrary to popular belief, the Great Himalaya is a zone of semiarid to arid conditions on the basis of precipitation (i. e., 10 to 15 inches of rain a year). The tremendous variety in topography, plus the large elevation differences (sometimes 26,000 ft), greatly modifies the climate of the Himalaya themselves. Rainfall is chiefly related to the monsoonal rainfall in India, and the Himalaya receive the greatest portion. There is more rain for a longer season in the east than in the west. The east may have 50 to 80 inches of rain upon the southern slopes and in certain spots even higher totals are reached. For example, Darjeeling averages 120 inches a year. The rainfall diminishes westward

to 40 inches where the Ganges leaves the mountains and falls even more, to about 30 inches a year, where the Indus leaves the mountains. The great vertical zonation of the Himalaya is reflected also in soil and vegetation characteristics. It is interesting to note that one-half of the total air mass of the atmosphere and three-fourths of the water suspended in it, in the form of vapor, lie below the average elevation of the Himalaya. Of the remainder, one-half of the air and virtually all of the water vapor come within the influence of the highest peaks. The general relationships of temperature and elevation indicate the following:

1. The decrease of temperature with elevation is most rapid in the summer.
2. The daily temperature range diminishes with elevation.
3. The annual temperature range diminishes with elevation.

Snow line in the Himalaya is directly related to climate as well as slope exposure. In the Kumaun Himalaya the snow lies about 3,000 ft lower on the southern slopes than on the northern slopes. In the Bhutan Himalaya the difference is also about 2,000 ft, but the snow line is higher on both slopes because this region lies in the rain shadow of the Khasi and Jaintia Hills. In the Punjab Himalaya of the same range, the difference is again about 2,000 ft and the snow line is higher, as a result of the Pir Panjal. The snow line on Mt. Everest is approximately 18,000 ft, while on the Nanga Parbat it is below 16,500 ft.

In the eastern part of the Himalaya intertropical plants reach an elevation of 7,000 ft and forests extend to nearly 13,000 ft. In the west similar varieties approach 5,000 and 12,000 ft respectively. Tundra-type vegetation is found in the Himalaya as high as 17,500 ft.

While the Himalaya appear to be an impenetrable barrier between the Tibetan Plateau and Central Asia to the north and the Indian subcontinent to the south, close inspection shows this barrier not to be impenetrable. Over 60 passes, by which man has and continues to maintain intercourse between the southern slopes and the northern slopes, exist in the chain. All are between 5,000 and 20,000 ft, the majority being between 14,000 and 15,000 ft above sea level. Many important passes, such as those in Bhutan, are between 15,000 and 20,000 ft. These passes are either at the gorges of major rivers that rise in Tibet or are snow-free depressions in the crest of high glacier-covered and snow-covered depressions or passes. For example, in the Punjab Himalaya alone there are over 20 passes that are important to trade, pilgrims, and transport between the Gangetic plain and the Tibetan Plateau. In Kumaun Himalaya there are 3 important passes, in the Nepal Himalaya over 25, in Sikkim there are 5, and in the Assam Himalaya approximately a dozen passes. In the Punjab Himalaya the lowest notch in the range is the Zoji La (11,578 ft) on the main caravan route from Srinagar to Central Asia. It, along with the distant Karakoram Pass in the Trans-Himalaya, is said to be the route of Genghis Khan. Mana Pass (18,400 ft), north-northwest of Nanda Devi (25,645 ft), was the pass used by Portuguese

Jesuits in the early 16th century to reach the Tibetan Plateau. It is also a pass that is historically important for Hindu pilgrims enroute to the worshipping areas in Tibet. Annually over 12,000 Indians including pilgrims and traders had reached western Tibet through various passes, a significant fact if one considers the routes across the Himalaya. Today the traffic has been closed by the Chinese Communists. In Nepal the Trisuli Gandaki drainage has been taken by both Tibetan and Nepalese armies in their invasions of each other's country. In the Mt. Everest area in northeastern Nepal the Nangpa La (19,050 ft) has been an important trade route over the watershed and it is one by which Sherpa porters from Namche Bazar in Solu Khumbu joined pre-World War II Everest expeditions in Tibet. The Jelep La (14,000 ft) in Sikkim and Tang La (15,219 ft) in Bhutan were passes taken by the Younghusband mission to Tibet in 1903 and were important for British mountaineering expeditions approaching Everest from the north before World War II. In 1936 Kenneth Mason listed 13 important passes across the Himalaya.

Mason wrote: "If we examine the state of motor development we find on both sides of the mountain barrier that good roads have been constructed in a few instances and surveys have been made for extension of such roads further into the hills, but no one has yet succeeded in getting wheeled traffic across the whole barrier. The existing method of transport is by pony, yak, sheep, or man, and very few of the land routes are opened for more than six months of the year. There are high, snow-bound passes and profound gorges to be traversed. Some of the less important routes are full of difficulties; the rivers, being unbridged, are only crossed by rope-suspension bridges. In the densely forested east a track may be taken along a hillside on bamboo platforms. In the drier regions of the west the track may climb over the barren precipices a thousand feet above the rivers." This was the situation then but, as detailed below, it has since changed in some respects.

Dr. L. G. C. E. Pugh, physiologist on the British Mt. Everest Expeditions in 1953, wrote: "In April, May, and June the effect of the strong insulation of the Indian Plains extends upward; there is a more or less sudden break in the frequent precipitation over the Himalayas and the weather becomes much warmer. The advent of the monsoon in the first half of June brings moisture and still warmer conditions, but precipitation is still less than in the cold weather season. In October there is another interval of fine calm weather between the end of the monsoon and the onset of the winter storms. On account of the frequent blizzards and heavy deposit of soft snow at high altitudes, mountaineering expeditions (and I interject travel in general) can only operate during these fine periods. Of the two, the May-to-June period is preferred since the weather is warmer at high altitudes." This assessment by Pugh is applicable not only to the Mt. Everest region but also the Himalaya in general and has a bearing on the times of year that pass-crossing can be undertaken. Traveling is often disrupted by the avalanche danger above tree line, and travel in the river valleys is sometimes difficult because of monsoon floods. Despite the difficulty of Himalayan travel it may be said that no mountain range is ever a perfect barrier against every kind of invasion. While it separates nations and prevents normal commerce and intercourse between

peoples, it has never been an insuperable obstacle against the penetration by a determined enemy who has the resources of a powerfully organized state behind him.

Today the Chinese Communists in Tibet possess a well-developed east-west road system just north of the main Himalayan chain. From the northwest behind the Karakoram Range in the Trans-Himalaya to Assam (the Northeast Frontier Agency), many feeder roads lead south from the main east-west motorable highways to the Himalayan passes. A case in point is Nepal, where the potentialities for military action against Nepal by the Chinese Communists are heightened by their new strategic road constructed parallel to the Nepal-Tibetan boundary about 50 miles inside Tibet. At least five feeder roads lead southward from this main road through passes into Nepal. One of these roads, via Kodari, links Katmandu with the Tibetan Plateau by motorable road.

Similar situations exist on the Sikkim-Tibet border, the Bhutan-Tibet border, and the Assam-Tibet border, as well as in Ladakh. The importance of the pass system of the Himalaya and the road system of Tibet became very apparent during the period of the Chinese invasion of India in 1962, which penetrated both Ladakh and NEFA (Northeast Frontier Agency).

Alaska Reconnaissance

The early stages of the Arctic Institute reconnaissance in late June and early July of 1966 were a series of light-aircraft flights in the St. Elias Mountains, the Wrangell Mountains, and the Chugach Mountains. An area of approximately 100,000 square miles was covered. The objective was to find an area or areas that were, in the opinion of the observers, as analogous to more than one area of the Himalaya as possible. Moreover, the attention of the observers was focused on areas that were as similar as possible to those zones of the Himalaya where man normally operates, and have similar drainage patterns, valleys, and passes. The observers were not concerned with mountain peaks, since these are important only to the mountaineer. The chief concern was physiographic expression including topography, vegetation, soils, and glaciation. More specifically, analogies were sought in grain, relief, texture, slope, glacier cover, tree line, snow line, and climate. This reconnaissance indicated that one area appears from the ground and from the air to encompass a variety of features strikingly comparable to those found in several areas of the Himalaya.

The area is a 60 by 60 mile zone, bounded longitudinally by 141°W, which is the international boundary between Alaska and the Yukon, and 143°W, a meridian running through the summit of Mt. Regal in the Wrangell Mountains. It extends from 60°55' to 61°50' N. Physiographically the area is delimited by the Chitina River valley on the south, the White River drainage plain on the northeast, the crest of the Wrangell Mountains on the west and northwest, and the international boundary and the north-south transect of

the St. Elias Mountains on the east and southeast. Within this study area attention focuses on the Chitistone valley which is the demarcation between the Wrangell Mountains and St. Elias Mountains according to the physiographic divisions of Alaska by Clyde Wahrhaftig.

The Wrangell Mountains are a great mass of Cenozoic volcanic rocks that rest on deformed Paleozoic and Mesozoic sedimentary rock, among which are cliff-forming units of limestone and greenstone. Some granitic masses intrude the Mesozoic rocks. The Wrangells rise above a low plain on the north and west and above heavily glaciated cliffs in castellated ridges on the south and east. The highest peak of the range is Mt. Blackburn, 16,523 ft in elevation. Six volcanoes at an altitude higher than 12,000 ft are present. Seventy-five percent of the drainage in this mountain range is into the Copper River and its tributaries which circumscribe the mountains on the southwest. There are in the Wrangell Mountains a few rock-basin lakes in the extreme northern part. Several ice-margin lakes lie in the Skolai Pass at the east end of the mountains. Snow line is about 8,500 ft. Ice fields cover most of the high mountains and feed the large valley glaciers; rock glaciers are common in the southeastern part of the range. Permafrost is probably present in some of the glacier-free areas but at present its extent is unknown.

The St. Elias Mountains, shared by Alaska and Canada, form a distinct physiographic province set off by rather arbitrary boundaries from the Coast Range on the southeast and from the Chugach and the Wrangell Mountains and the Alaska Range on the northwest.

The highest coastal mountains in the world are the St. Elias Mountains. Between Mt. St. Elias and Mt. Fairweather the international boundary follows the crest of the chain at an average distance of only 30 miles from the coast. In that segment are found such impressive features as Mt. St. Elias (18,008 ft), Mt. Vancouver (15,700 ft), Mt. Fairweather (15,300 ft), and Mt. Hubbard (14,950 ft). Within the St. Elias Mountains are located the second and fourth highest peaks on the North American continent (Mt. Logan, 19,850 ft and Mt. St. Elias), as well as 12 other peaks that exceed in altitude the highest in the continental United States.

The St. Elias Mountains are about 300 miles long, and have a maximum width of about 100 miles, excluding the coastal plain and foothill belt. Near the Alaska-Yukon border, the mountains merge with the Chugach and the Wrangell Mountains and with the Nutzotin Mountains of the Alaska Range.

To quote D. J. Miller: "So rugged and difficult of access are the St. Elias Mountains that little is known of their geology. Reconnaissance investigations in the Fairweather Range, around Yakutat Bay, and in the northwestern part, together with information gained by climbing expeditions, indicate that the mountains consist mainly of bedded sedimentary and volcanic rocks of Paleozoic and Mesozoic age. These rocks have been altered by deep burial and by heat

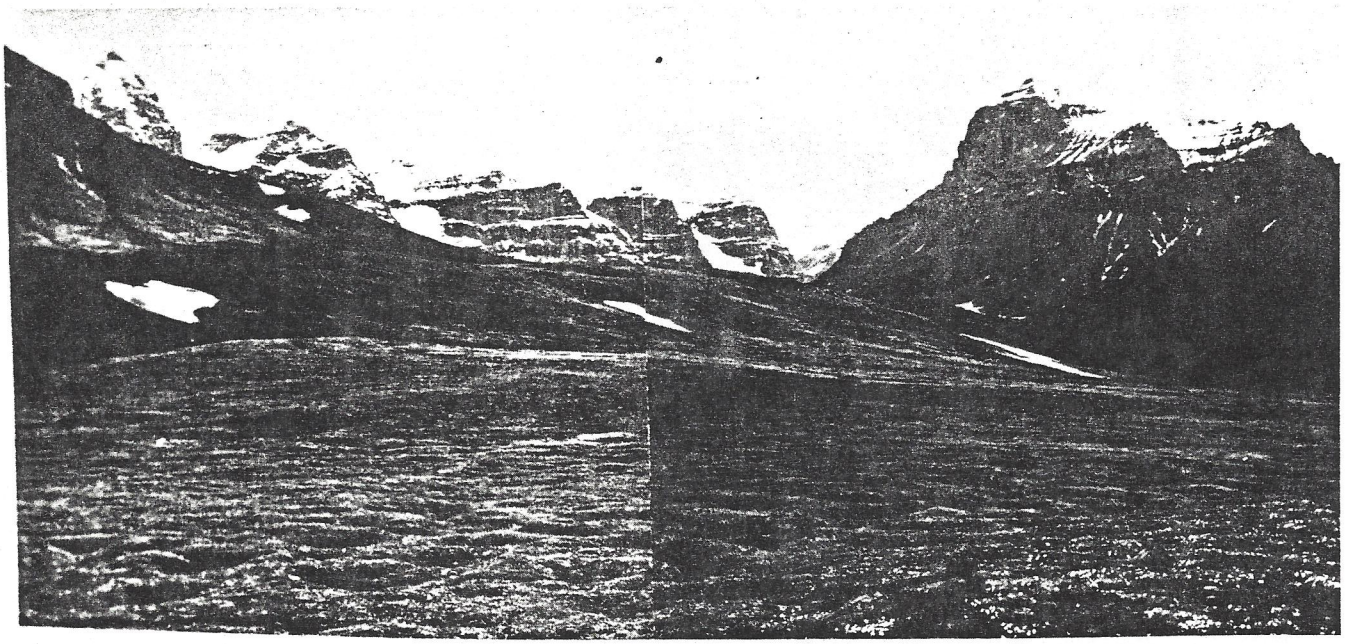
and mineralizing solutions emanating from bodies of intrusive igneous rocks such as now form many of the high peaks" (in Williams, 1958, p. 21).

Within the broad study area described above, three specific sub-study areas were selected:

The Chitistone Area
The Glacier Creek Area
The Mt. Bona Area (See Map 3)

Chitistone Study Area

The Chitistone study area is bounded on the west by the Hole-in-the-Wall glacier, on the east by the eastern glaciated slopes of Mt. Sulzer (10,926 ft), on the south by the upper reaches of the Russell Glacier system, and on the north by the outwash plain of the Russell Glacier, the White River valley. It is centered on the lower ablation zone of the Russell Glacier and contains the lower 12 miles of that large body of ice. The southeastern third of the Chitistone study area is



CHITISTONE PASS, 5,800 FEET



CHITISTONE GORGE



MAJOR RELIEF IN UPPER PORTION OF CHITISTONE RIVER VALLEY

predominately glaciated and resembles in its valley glaciers the size and extent of the glaciers found in the Trans-Himalaya, particularly the Karakoram. Of singular interest for the purposes of this Himalayan analogue study is the southwestern quarter of the Chitistone study area comprising Skolai Pass, Chitistone Pass, and the upper reaches of Chitistone Creek. Skolai Creek originates at an elevation of 4,440 ft at Upper Skolai Lake (on the western margin of the Russell Glacier) and flows west-northwest into the Nizina River. The drainage of Skolai Creek is braided, somewhat disarranged, and underfit in a broad glacial alluvial plain, the valley of a former large glacier. The upper five-mile portion of Skolai Creek has a very slight gradient and is braided along this outwash that is a mile in width.

Chitistone River originates in a little tarn at 5,805 ft in Chitistone Pass and flows southwest into the Nizina River. Chitistone Pass is on the southern flanks of the Skolai valley and is 1,300 ft above the Skolai outwash plain.

The upper reaches of the Chitistone River are fed by several very small retreating glaciers and by some snow accumulation fields on the southeast flank of the Hole-in-the-Wall glacier mountain system, which has a crest at approximately 9,000 ft. On the southeast three larger glaciers of three- to four-miles length feed the Chitistone. The crest on this side of the valley is approximately 8,500 to 9,000 ft in elevation. The Chitistone River in its upper seven miles occupies a V-shaped valley. Relief between the upper reaches of the Chitistone and the tarn lake in the Chitistone Pass is two to three thousand feet, while seven miles downstream, relief is some six thousand feet; in the second two miles a drop of a thousand feet; and in the final mile above Chitistone falls a drop of a thousand feet presenting an increasingly steeper drainage as the Chitistone flows out of the broad tundra of the Chitistone Pass.

The mountain slopes in the vicinity of Skolai Pass are very luxuriant. Lichens and mosses are especially well developed. Dwarf woody species and herbs together with cryptogams form deep, continous mats. The largest woody plants, the willows, are six to seven feet tall and are restricted to the borders of water courses on the extensive gravel bars at the head of Skolai Creek. Willows also extend up the mountain slope but only as far as the shelter of stream-cut gulleys permit. The steepest slopes are covered with the debris of rockfall and are dissected by gulleys that give every indication of being torrential streams during runoff maxima.

On the flood plain where Skolai Creek has not incised for some time, there are large areas of standing water with emergent aquatic plants, extensive moss mats, and widespread ground ice. The Skolai Pass is approximately 5,000 ft above sea level.

At the head of the Chitistone River, only a short distance from Skolai Pass, a greater variety of habitats is found. The Chitistone Pass is at approximately 6,000 ft elevation. Well-drained ridges and morainal material approach a fell-field condition. The valley of the Chitistone becomes steep and narrow very quickly until it forms a rock canyon just before reaching the Chitistone Glacier. The relationship of angle of slope, slope stability (or rather the lack of it) and vegetation patterns is well demonstrated.

The Chitistone study area and the Glacier Creek study area come together at the Chitistone falls or Chitistone gorge. Chitistone gorge, in which the falls drop for some 1,500 ft in a very short horizontal distance, is deep, narrow, and vertical-sided. The entire length of the Chitistone River from Chitistone Pass, including the upper Skolai Pass and Skolai Creek zone, is highly analogous to many of the drainage systems found in the Himalaya. It is an ice-free pass zone of tundra vegetation. Travel is extremely difficult in this area; one cannot go through the Chitistone gorge, but is forced to find a trail in some cases a thousand feet or more up the northwestern slopes of the Chitistone valley. River-crossing in this area is extremely hazardous and one must follow tributary streams high into their source or catchment basin before being able to cross. This is reminiscent of a great deal of the drainage in the Himalaya from Bhutan to Ladakh. A trail of historic importance goes through the Chitistone Pass and the Skolai Pass. This is the Goat Trail. It was used by travelers with pack horses to go from the interior to the coast and is in itself very analogous to tracks in the Himalaya.

In the Skolai Pass and the Chitistone Pass, and in the zone of drainage of the upper Chitistone River through the Chitistone gorge, there is a definite elevational relationship between the soil, vegetation, glaciation, tree line, and snow line and the analogous situation in much of the Himalaya and the Tibetan Plateau. If we subtract 10,000 ft from an ice-free pass in the Himalaya such as the Natu La in Sikkim we have the situation of the Chitistone Pass. The Chitistone Pass at 5,800 ft above sea level appears analogous to many situations in the Himalaya at 15,800 ft. What we find in the Chitistone gorge at 3,000 ft to 4,000 ft we find to be similar to the upper reaches of the Rishi Gorge in the Garwal Himalaya at 13,000 to 14,000 ft. Reconnaissance in the summer of 1966 in Alaska indicated that this 10,000-ft difference is manifest in all three study areas selected.

Mount Bona Study Area

The Mt. Bona study area encompasses some 240 square miles and contains the 16,500-ft summit of Mt. Bona in the St. Elias Range. The northern two-thirds of this study zone are the upper reaches of the Russell Glacier system. The southern fourth of this study zone is comprised of the



"BRENT" PASS AT 10,000 FEET ELEVATION

University of Alaska Range which is the headwall crest area for the most westerly of the Russell Glacier cirques. It includes University Peak, 14,470 ft, and such glaciers as the Hawkins Glacier, which flows south. The southern fourth of the Mt. Bona study area is an extremely rugged mountain glacier system with great relief between small cirque glaciers and serrated mountain peaks. The size, configuration, relief, and dynamics of the small glaciers flowing south from the Mt. Bona highland closely resemble the mountain zone of the Great Himalaya in most of its extent excluding the Karakoram Range. The Russell Glacier, however, flowing north, closely resembles the larger glacial expression of the Karakoram. A glacier-covered pass at approximately 10,000 ft in the University of Alaska Range is the center of attention of this particular study area. Here we find a pass that is reached from the north by a gently rising glacier moderately crevassed, and a cirque

catchment zone that drops off to the south very steeply through an ice-fall that is heavily crevassed into the Glacier Creek glacier. For convenience this pass will be referred to as Brent Pass. Brent Pass was selected as being representative of the type of high glacier-covered pass found in the Himalaya between 16,000 and 20,000 ft that is negotiated by both men and animals. Russell Glacier cirque to the immediate north of Brent Pass is a very large catchment zone some 16 square miles in extent.

The headwall of the Glacier Creek glacier immediately to the south of Brent Pass drops steeply in two stages from the pass itself at 10,000 ft to the 6,500 foot level. The second or lower stage is an extremely hazardous icefall, menaced by continual avalanches from the peaks on the eastern side of the valley. Such glacier passes are common in the Himalaya. An example of this would be the Nangpa La in the Mt. Everest region of northeastern Nepal. The Nangpa La is the normal trade route from the Sherpa area of Khumbu to the Tibetan villages on the north side of the Mt. Everest massif. The peaks of the University of Alaska Range, particularly their southern flanks, and University Peak, show a strong resemblance to peaks 10,000 ft higher in elevation in the central Himalaya. The scale of relief is quite similar.

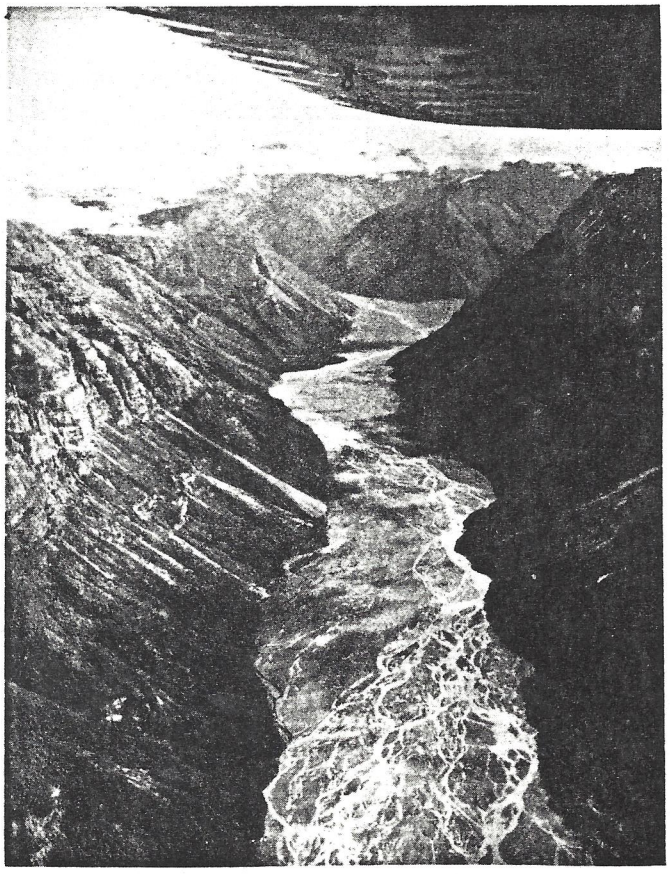
Glacier Creek Study Area

The Glacier Creek study area overlaps the Chitistone study area at the Chitistone gorge and Chitistone falls, and overlaps the Mt. Bona study area at the upper reaches of the Glacier Creek glacier. Covering an area of 180 square miles it includes the Chitistone River drainage from Chitistone gorge to the entrance of Glacier Creek and the entire Glacier Creek drainage system. The Glacier Creek glacier is 11 miles in length, and flows in a general west-northwest direction into Glacier Creek. It is almost a textbook example of a mountain glacier with dendritic catchment glaciers in its upper reaches. It is fed by eight of these tributary glaciers. Relief above the Glacier Creek glacier averages about 6,000 ft. A profusion of glacial depositional forms is present in the lower five miles of the glacier below the firn line. There is massive lateral morainal development and a terminal morainal recession zone of about one mile. This glacier drops 3,000 feet in 11 miles. From its terminus the drainage of Glacier Creek glacier flows for another five miles into the Chitistone River. This outwash stream is constricted in its upper zone in a very narrow V-shaped valley but as it nears the Chitistone River, the valley widens to a half mile in width. At this lower end is located the Glacier Creek airstrip, 2,360 ft above sea level. From the outwash plain of Glacier Creek trees grow on the side slopes to an elevation of 4,000 ft on the southwest-exposed slope.

This drainage closely resembles drainages like the Mingbo drainage in the Mt. Everest region and at the first appraisal would appear to be



CHITISTONE RIVER BETWEEN CHITISTONE GORGE IN FOREGROUND AND GLACIER CREEK IN BACKGROUND



CHITISTONE RIVER BETWEEN NIZINA RIVER AND GLACIER CREEK

closely analogous to the type of small valley glacier found in the Himalaya both in extent and scale and in geomorphological processes.

Also included in this Glacier Creek study area is the nine-mile section of the Chitistone River between Chitistone gorge and the entrance of Glacier Creek. In this segment the Chitistone River drops only 700 ft. Fed by the runoff from the Chitistone Pass area and from Chitistone Glacier the Chitistone River and its tributaries drain the northwest corner of the University of Alaska Range and the Glacier Creek drainage. The Chitistone River is a fast-flowing, braided outwash stream that changes direction often during times of maximum runoff. The alluvial plain of this river varies between a quarter and a half mile in width, and presents river-crossing problems almost identical to those experienced in the lower reaches of south-draining Himalayan streams in Punjab, Kumaun, and Nepal Himalaya. This area shows a very close similarity to the Spiti area of the Punjab Himalaya. The Chitistone River in this section flows in a west-southwest direction. Vegetation on both sides of the Chitistone River is found up to 3,000 to 3,500 ft up the valley walls presenting a barrier to travel. The Chitistone River itself forces one to leave the outwash plain of the river on many occasions. Here again there is an analogy between travel in a drainage of this type in Alaska and in the Himalaya. Here, too, the 10,000-ft differential is evident.

Area for High Elevation Physiology Studies

The high slopes of Mt. Logan lend themselves to the conduct of research in human physiology on problems associated with living and working at high elevations. By aerial observation areas suitable for field stations were found at approximately 11,000 and 16,000 ft, and up to 19,000 ft. Discussions with mountaineers who have visited the area confirm the opinion of the reconnaissance group.

The sites tentatively selected on Mt. Logan are large enough for extensive outdoor activities and are remote enough from developed areas to give test subjects a true sense of isolation from civilization.

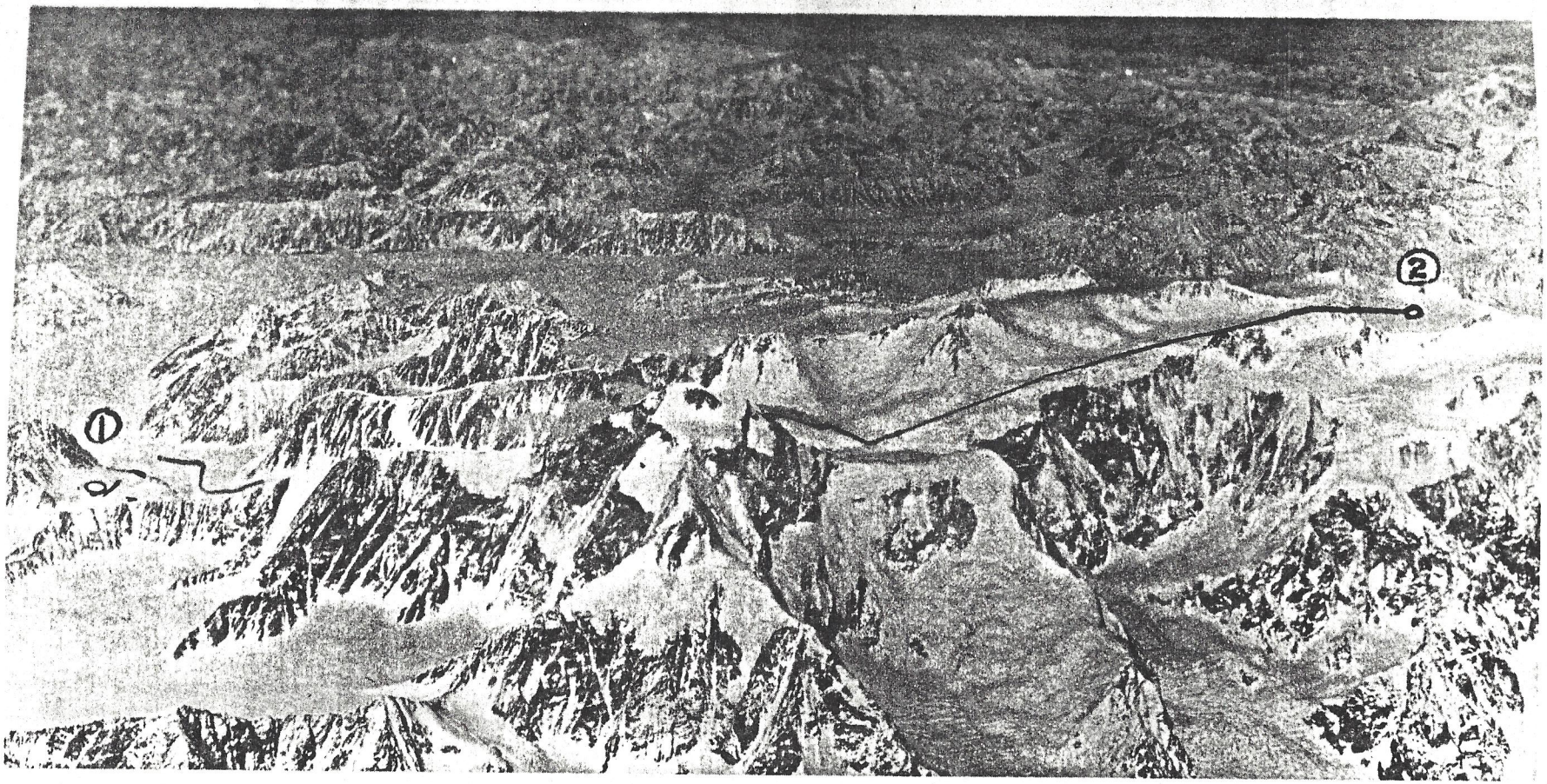
Mt. Logan, the highest summit of Canada (19,850), is the most massive mountain in the Western Hemisphere and, in the opinion of many, of the world. Its relative obscurity among the great mountains of our planet stems from the fact that, unlike Mt. McKinley, Aconcagua, or Mt. Blanc, it is masked by lesser peaks and ranges from the view of travelers following the routes of trade and tourism both in the Yukon Territory and in coastal Alaska. Only from the air or from within the boundaries of the Icefield Ranges does its isolated magnificence set it apart from the other great peaks of the St. Elias Mountains.



MOUNT LOGAN, ST. ELIAS MOUNTAINS, SOUTHWESTERN YUKON TERRITORY. CANADA



16,000 FOOT HIGH PLATEAU ON MOUNT LOGAN SUITABLE FOR AIRCRAFT LANDING



MOUNT LOGAN STUDY AREA

1. Approximately 9,000 foot level at head of Ogilvie Glacier. This is a good site for an emergency camp and acclimatization camp.

2. Approximately 16,000 foot level on high plateau of Mt. Logan

The base of the mountain is a roughly rectangular block of rock, 15 miles long, six miles wide, and 8,000 ft high, sitting atop a glacier highland 7,000 ft high. On top of the block is a mountain range of undulating peaks 5,000 ft high. A high mantle of glacier ice, whose continuity is broken by the precipitous walls of the base block, covers the top of the mountain.

The geometrical symmetry of Mt. Logan is broken on its western wall by a glacier-filled valley that drains the ice of the high slopes. This is the Ogilvie Glacier and its trench, which separates King Peak from the mass of Mt. Logan. It is this avenue that provides relatively easy access to the broad snow apron that mantles the mountain above 14,000 ft. The profile of the King Col trench is one of gentle gradient, punctuated by a series of glacier steps or icefalls. The relatively flat areas are 2 to 3 miles long and the slope is so gentle that little crevassing occurs. Even the ice fields pose no serious problem in an ascent and, indeed, an over-snow vehicle has been driven from the 10,500-ft level to King Col at about 13,000 ft. Aircraft landings have been made on the glacier at 9,000 and 10,500 ft and the higher surfaces appear to present no serious operational problems to aircraft equipped to perform at these elevations.

Above King Col is the "Mountain Range", which rises above the base. Here the glacier slopes sweep down the "roof" of Mt. Logan, and while slopes are moderate they offer little opportunity for aircraft landings. At 16,000 ft, however, the landscape softens into a series of smoothly molded ridges, valleys, and terraces, with the last apparently offering a number of favorable landing sites between 16,000 and 19,000 ft.

There is no doubt that Mt. Logan provides a unique opportunity in North America for high elevation studies above 15,000-ft elevation. Studies of acute mountain sickness or acclimatization can be carried out.

It would be desirable to have laboratory facilities available at 11,000 and 15,000 ft above sea level. These elevations are desirable since there is already a large body of information available from work carried out in Peru and elsewhere. In La Ovoya, Peru, at the Chulec Hospital, many studies of both acute and chronic mountain sickness have been done. Studies in Movococha, Peru, have been carried out at 15,000 ft.

When facilities and a logistic support system have been established on Mt. Logan, at the 11,000- and the 16,000-ft elevations, work areas up to 19,000 ft can be developed. This latter elevation is adequate to duplicate the altitude stress that might be encountered by any surface operation in the important passes and trade routes of the Himalaya or other mountain systems.

Opportunities for Defense-Oriented Activities in the Study Areas

The Chitistone area, the Mt. Bona area, and the Glacier Creek area, as defined in this report, seem to the observers to be reasonably analogous to operational areas of the Himalaya. Environmental studies should be made in the above areas to determine the validity of the apparent analogies.

Assuming that the analogies are proved valid from an operational standpoint, there are several research projects that could be accomplished there. For example, the logistical support of mountain troops would be enhanced by extensive use of light aircraft, both rotary and fixed-wing. It is well known that air turbulence is a major problem in operating light aircraft in mountainous areas. Research should be initiated to determine the relationship that exists between intermontane air turbulence, landforms, and the regional weather conditions. Another problem area is the matter of radio communication by means of low-power portable equipment.

It is well known that acute mountain sickness would make the majority of troops more or less ineffective for the first few days at elevations above 12,000 ft especially if they were flown to such areas from considerably lower elevations. Areas suitable for field stations have been identified at approximately 10,000 and 16,000 ft on Mt. Logan. Also, the high slopes of the mountain above 16,000 ft offer many areas for aircraft landings and outdoor activities up to approximately 18,000 ft.

A research facility could be established on Mt. Logan to accommodate physiological studies as required to satisfy Army interests.

It is believed that the Chitistone, Mt. Bona, and Glacier Creek areas could be used for testing and evaluation of appropriate Army supplies and equipment that are not affected by the reduced air pressure of high elevations. Specialists could be trained in these areas at elevations where they are capable of receiving instruction without suffering from altitude stress. At the conclusion of the training period, they could be flown to the 16,000-ft, or higher, level of Mt. Logan to experience the effect of high elevation and to be tested for ability to acclimatize.

The proposed test area is convenient to reach by air from Fort Greely and from Anchorage in Alaska and from Whitehorse in Canada. Participation in the above-suggested programs by the Army Arctic Test Center and the Arctic Indoctrination School at Fort Greely and the Combat Development Agency at Fort Richardson could be relatively easy.

Conclusion

The area east of May Creek, Alaska, bounded on the north by the Nizina River and Skolai Creek, on the south by the Chitina River, and on the east by the Alaska-Yukon border, appears from ground and air reconnaissance to present a variety of features strikingly comparable to those found in important areas of the Himalaya. (See Map 2.) Also, there are areas on Mt. Logan appropriate for the conduct of research in human physiology on problems associated with living and working at high elevations. Areas suitable for field stations were found at approximately 10,000, 17,000, and 18,500 ft.

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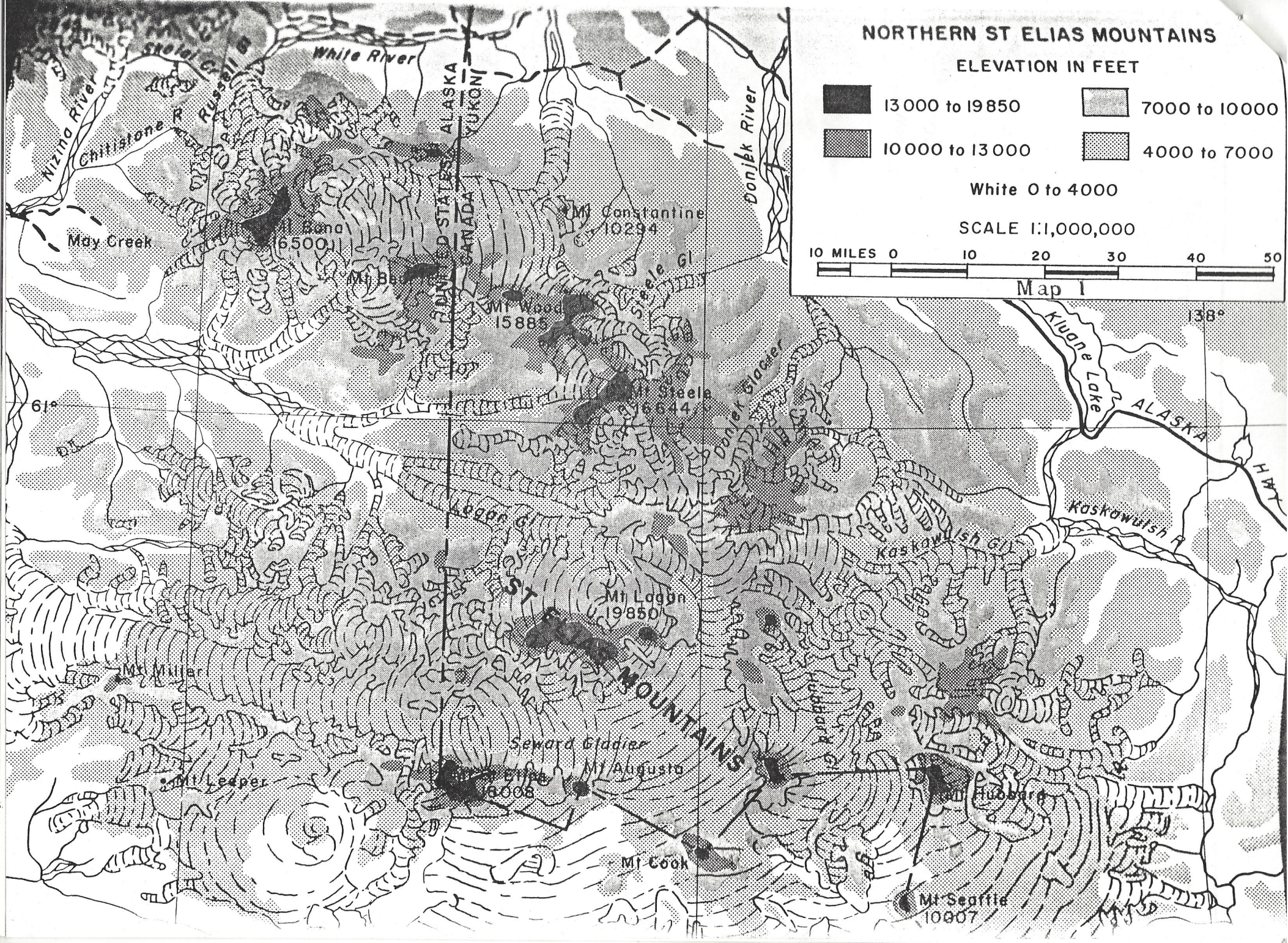
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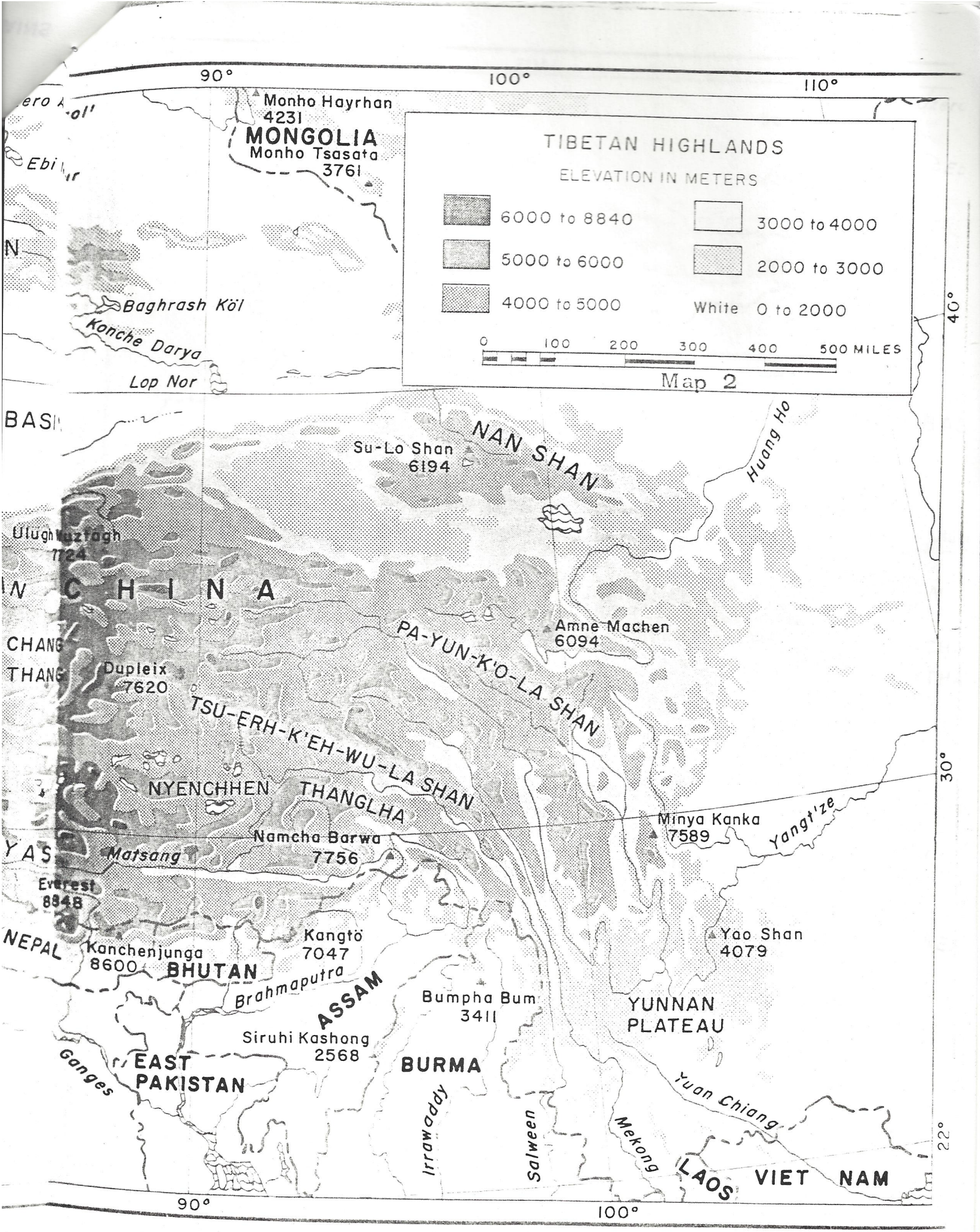
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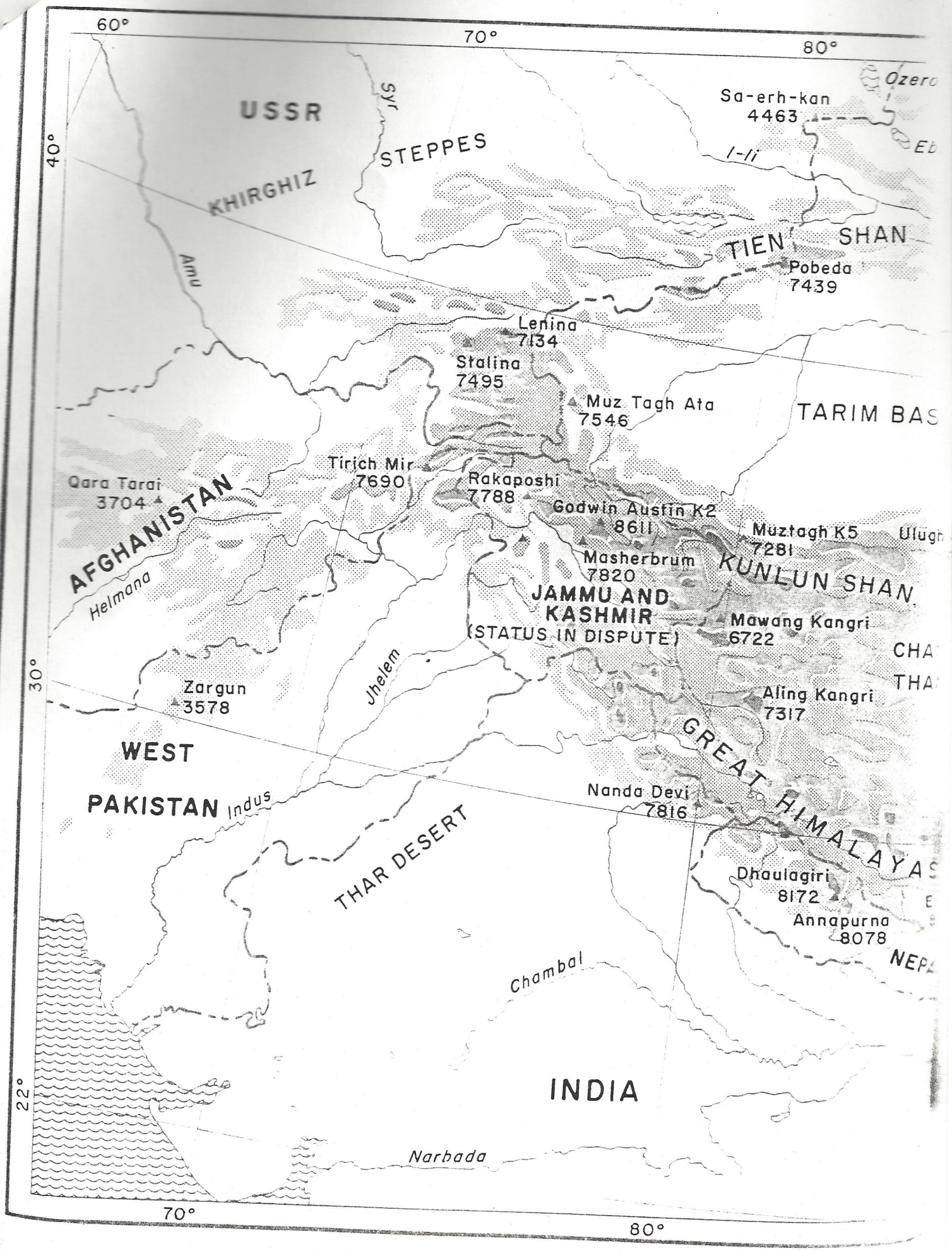
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NORTHERN ST ELIAS MOUNTAINS
ELEVATION IN FEET
13000 to 19850
10000 to 13000
7000 to 10000
4000 to 7000
White 0 to 4000
SCALE 1:1,000,000
10 MILES 0 10 20 30 40 50
Map 1
White River
Nizina River
Chitistone R
Russell G
Stolat G
ALASKA
YUKON
UNITED STATES
CANADA
Donjek River
May Creek
Mt Bona
16500
Mt Constantine
10294
Mt Wood
15885
Steele Gl
Mt Steele
16644
Donjek Glacier
Kluane Lake
ALASKA
HWY
138°
61°
Logan Gl
Kaskawulsh Gl
Kaskawulsh R
ST ELIAS MOUNTAINS
Mt Logan
19850
Mt Miller
Seward Glacier
Mt Augusto
Mt Lucania
16008
Mt Hubbard
Mt Cook
Mt Seattle
10007


TIBETAN HIGHLANDS
ELEVATION IN METERS
6000 to 8840
5000 to 6000
4000 to 5000
3000 to 4000
2000 to 3000
White 0 to 2000
0 100 200 300 400 500 MILES
Map 2
90°
100°
110°
40°
30°
22°
Monho Hayrhan
4231
MONGOLIA
Monho Tsasata
3761
Ebi
Baghrash Köl
Konche Darya
Lop Nor
BASI
Su-Lo Shan
6194
NAN SHAN
Huang Ho
Ulugh Muztagh
7724
N C H I N A
CHANG
THANG
Dupleix
7620
PA-YUN-K'O-LA SHAN
Amne Machen
6094
TSU-ERH-K'EH-WU-LA SHAN
NYENCHHEN THANGLHA
Minya Kanka
7589
Yangt'ze
YAS
Matsang
Namcha Barwa
7756
Everest
8848
NEPAL
Kanchenjunga
8600
Kangtö
7047
BHUTAN
Yao Shan
4079
Brahmaputra
ASSAM
Bumpha Bum
3411
YUNNAN
PLATEAU
Siruhi Kashong
2568
Ganges
EAST
PAKISTAN
BURMA
Yuan Chiang
Irrawaddy
Salween
Mekong
LAOS
VIET NAM


60°
70°
80°
40°
30°
22°
USSR
Syr
STEPPES
KHIRGHIZ
Amu
Sa-erh-kan
4463
Ozero
I-li
TIEN SHAN
Pobeda
7439
Lenina
7134
Stalina
7495
Muz Tagh Ata
7546
TARIM BAS
Tirich Mir
7690
Qara Tarai
3704
AFGHANISTAN
Rakaposhi
7788
Godwin Austin K2
8611
Muztagh K5
7281
Ulugh
Masherbrum
7820
KUNLUN SHAN
Helmana
JAMMU AND
KASHMIR
(STATUS IN DISPUTE)
Mawang Kangri
6722
CHA
THA
Zargun
3578
Jhelem
Aling Kangri
7317
WEST
PAKISTAN
Indus
GREAT HIMALAYAS
Nanda Devi
7816
THAR DESERT
Dhaulagiri
8172
Annapurna
8078
NEPA
Chambal
INDIA
Narbada