Abstract

From 2 to 14 June 1980 the authors participated in an excursion by jeep across Tibet, following the road from Lhasa via Gyantze, Xigaze, Tingri, and Nyalam to Zham on the Nepal border. The excursion was organized by the Academia Sinica, with direct support by Vice-Chairman and Vice-Premier Deng Xiaoping and Vice-Premier Feng Yi, and relied on the excellent logistic support of the Chinese People's Liberation Army. This report gives an account of impressions, including those of local and regional meteorological and climatological problems.

Xizang (Tibet) holds a fascination for Chinese and Westerners alike. The world’s highest mountains (Qomolangma, also known as Mt. Everest, 8848 m; and a host of other 8000-plus meter peaks) guard the southern access routes to the “roof of the world.” The average elevation of the Qinghai-Xizang plateau exceeds 4500 m. Its brackish lakes are remnants of the Tethys Sea of the Eocene Epoch. Major river systems are confined to the periphery of the plateau. Here some of Asia’s largest rivers have their headwaters: Indus, Ganges, Brahmaputra (Yarlung Zangbo), Mekong, Yangtze, and Hwang Ho, just to mention the major ones.

Most of the mystery surrounding Tibet stems from the fact that its theocratic society, headed by a powerful lama caste, for centuries had maintained a careful vigil against peaceful as well as bellicose foreign intruders. Only a handful of adventurers and invaders provided glimpses of this forbidding country and its strange customs. With the Chinese advance into Tibet, which began in 1950, that country remained as inaccessible to foreigners as before, perhaps even more so.

Our surprise cannot be described when, in November 1979, we received an invitation to participate in a symposium on the Qinghai-Xizang plateau, to be held in Beijing in May 1980 and to be followed by an excursion by car through Tibet (see Fig. 1). One of the conditions for being accepted as a participant in the excursion was a certificate of good health by a physician, since for two weeks we would be traveling at altitudes in excess of 3600 m. Several passes over 5000 m had to be crossed, the highest one boasting an elevation of 5220 m. (Unfortunately, several in our small group took the Chinese admonition of a thorough health check too lightly. The Chinese and German doctors who accompanied us had their hands full with cases of general high-altitude sickness, and even pneumonia and heart attacks—no laughing matter when you are out in the “Boonies.” Our hosts deserve high credit marks, because in spite of adversities we did not lose anyone to the undertaker.)

Other than knowing that the plateau of Tibet plays a fundamental role in shaping the Asian monsoon systems, and

---

**FIG. 1.** Travel route through Tibet.

---

1Dept. of Atmospheric Science, Colorado State University, Ft. Collins, Colo. 80523.
remembering a sense of high adventure from Sven Hedin's books, Tibet to us was uncharted territory. Even the *Encyclopedia Britannica* (1974) left most of the recent history of Xizang a suspected blend of facts and rumors. Were the Chinese as oppressive and destructive to the Tibetan customs and way of life as refugee accounts made us believe? Was there anything worthwhile at all to be seen?

In retrospect, we found the accounts by Han Suyin (1977, 1979), even though they might have been slanted in favor of the Chinese, more credible than the newspaper stories of the 1950s and '60s, and even some of the descriptions of the “Chinese conquest” given by the *Encyclopedia Britannica*. It would be presumptuous if we attempted to settle the question of “right or wrong” after a two-week trip through Tibet. Even though we probably saw more of that country than any Westerner before us, we did not “live” with the natives. We talked to them through interpreters as we traveled with our Han hosts. We camped in Chinese military compounds, and not in nomad tents with the suffocating smoke of a yak-dung fire. In other words—we were as well taken care of as circumstances permitted. Therefore we should disqualify ourselves.

FIG. 2. Scenes from the Lhasa area: Tibetan temple art (Jokka Kang temple, Lhasa) provides a blend of Himalayan and Chinese origins (upper left); view of old Lhasa from the roof of Jokka Kang temple (lower left); firewood stores in a courtyard at Drepung monastery (upper right)—the head count of resident lamas presently stands at approximately 250, but used to be 10,000; west of Lhasa, the Drepung monastery nestles into a craggy mountainside (lower right).
as experts on Tibetan sociology. We should stress, however, that never, even for a minute, were we brainwashed on this trip. In fact, our Han hosts in many aspects were as curious and ignorant as we were, when we huffed and puffed our way through historic monuments, temples, palaces, and monasteries that we had never dreamed of seeing (cover and Fig. 2).

Many of the historic details that could not be provided to us on location we dug up in libraries after our return from this trip, which might have been just as well. It allowed us to stand in awe of a strange but magnificent culture, to taste the changes that are sweeping over Tibet with hurricane force, to drink in image after image, and to sort out and form our own opinions. If some of these opinions are wrong, we apologize to those offended. None of these opinions were forced upon us, however.

The spectacle of Tibet began shortly after takeoff from Chengdu (Sichuan Province) in our British-made Trident furnished by the Chinese government. Its leaders had wished us well two days before in a memorable reception in Ren Min Da Hui Tang (the Great Hall of the People). A steep climb brought us at eye level with the snow-covered peaks (> 6000 m) that provide a formidable barrier between Xizang and Sichuan. In bottomless gorges the Mekong and Brahmaputra force their way southeastward. The pilot had to order us back to our seats: Because of our constant running between port and starboard to shoot another picture the plane was wobbling crazily and a case of clear-air turbulence might have provoked a disaster. Fortunately, it did not happen.

Brilliant sunshine received us at Lhasa airport, which is approximately 100 km by gravel road to the southeast of
The stark beauty of the land overwhelmed us immediately, but also impressed us with some of the problems. The arid climate (200–600 mm of annual precipitation characterize the Transhimalaya and the Yarlung Zangbo regions) allows only a tenuous vegetation of grasses and low shrubbery along the hillsides. Even this meager vegetation is frequently interrupted by large sand dunes that creep up along the mountainsides, but also are found along the wide gravel stretches of the riverbeds. We suspect that some of this desertification is aggravated, perhaps also induced, by human activities. Almost every second vehicle or beast of burden that we met on our trip across Tibet was loaded down with firewood. More often than not that wood was actually freshly cut juniper from remote mountains. Whatever trees we saw north of the main range of the Himalayas were poplars and willows less than 20 years old, apparently planted by the Chinese along the roadside, in river valleys, and in villages. These trees were protected against foraging animals by low mud-brick walls.

These observations brought home one of the foremost problems of the Tibetan economy: the lack of fuel in a harsh environment. In the pastoral settlements yak dung, mixed with straw and pasted in patty-form against house walls for drying, is the major fuel source—next to brush and juniper hauled in from the mountains. The use of yak dung as fuel competes with its application as fertilizer. Even though lush fields of wheat and barley grow in the Lhasa Agricultural Experiment Station under plentiful application of urea, such technology has not yet impacted on the subsistence-type agriculture out in the valleys.

The foraging trips into the hills and mountains for fuel leave the countryside barren and denuded—open to wind and water erosion. We have seen plenty of examples of both. Sand dunes are the most conspicuous forms of aeolian erosion. In the Lhasa, Gyangze, and Xigaze areas these dunes were rather irregularly shaped, attesting to the occasional occurrence of strong winds, variable in direction. In the vicinity of Tingri (almost straight north of Qomolangma—Everest) we came upon a series of perfectly shaped barchanes (sickle dunes) that could only form with frequent strong winds from the southwest, blowing up the rather broad valley. That valley was by no means a desert. It was mostly high-alpine meadow, with some irrigated patches of farmland.

Lhasa (not to the north, as the Encyclopedia Britannica states). The high altitude, 3600 m, caused first symptoms of difficulties with some of our fellow travelers (about 80 participants from western countries and about 120 Chinese). A simple trip to the bathroom for some of the lowlanders turned into a “breath-taking” excursion. But our Chinese hosts were well prepared. Each of the small Chinese-built jeeps and the 15-passenger Toyota buses (they had left Beijing in mint condition three weeks earlier) carried a supply of oxygen-filled pillows.

FIG. 8. Chinese television crew on Karila Pass (5045 m).

FIG. 9. Hanging glacier descending from Mt. Noijinkangsang towards Karila Pass on a rainy day.

FIG. 10. Temple ruins in Gyangze.
Our conclusion was that reforestation of Tibet will be an important but perhaps futile task. It will have to be planned for many years, perhaps generations, into the future. To check erosion should be but one concern of such a revegetation program. Management of water resources should be the other focal point.

Much of the agriculture that we have seen has to contend with extremely poor and rocky soil conditions. Nevertheless, irrigation—some of it quite sophisticated—abounds, even at high altitudes (Fig. 3). Our hosts at the Experiment Station claim that, with much labor and Chinese advice, Tibet has become nearly self-sufficient in the production of cereal grains. Wheat and barley are planted near 4000 m. To count on a continuous water supply in the rivers during drought periods may at times be a problem, especially if there is little runoff from the previous winter’s poor snow cover. And snow cover varies quite a bit interannually in Tibet. Enhanced moisture storage on mountainsides protected by vegetation should provide at least some buffer against drought effects. It certainly should go a long way toward alleviating some of the erosion problems.

Most of the Tibetan villages sit on top of enormous gravel fans that spread at the mouths of relatively short (very few kilometers long) side valleys (Fig. 4). These gravel fans are usually cut by a deep, eroded ravine. The likely reason for this choice of building site is the accessibility of groundwater at the bottom of the gravel bed. In viewing such typical scenery one began to wonder where all that gravel came from, and how 200–400 mm of annual precipitation could ever move it down those short valleys. Our conclusion was that off and on these valleys must be visited with deluges, either from rain or from sudden snow melt—even though the relatively short records kept by the Chinese in this region don’t
changes are coming rapidly to Tibet. An important network of well-maintained gravel roads (built by the Chinese army with the help of local paid labor, the latter charged with maintaining the roads) constituted the foundation for these changes. There is plenty of coal in Tibet, one deposit being not far from Xigaze. The problem still is how to mine it and bring it to market. More modern forms of energy are gradually being developed. The guest house in Lhasa sported solar-heated hot water for several showers and a barber shop. A geothermal field (Fig. 5) that we visited in the Yangbajain fault basin approximately 90 km northwest of Lhasa is only one of the 40 or so high-temperature hydrothermal regions in the Himalayan geothermal belt (Organizing Committee, 1980). A high-voltage power line being erected in the Doilung Qu Valley leading from the Lhasa He (river) to that geothermal field attests to the seriousness with which the Chinese are attacking the energy bottleneck that hampers economic development in Tibet.

Strenuous labor in all this development work is exacting a high toll from the Han lowlanders, and also from their children, who suffer a high incidence of altitude-induced cardiovascular failure before they reach the age of two. Agricultural improvements should be possible, especially since the climate in most of Tibet’s major valleys is not any harsher than in many cereal-producing western states of North America. Livestock abounds, but overgrazing seems to be a bothersome problem. Sheep that provide wool (some of it going into magnificent handwoven and naturally dyed Tibetan carpets—mostly exported to Japan), goats (including a funny-looking dwarf variety), cattle, horses, and donkeys are ubiquitous. The yak (Fig. 6) climbs the higher slopes of the valleys. It provides wool for clothing, meat, butter for candles and human consumption (not one of our favorite staples, we must admit), leather, and fuel. But the higher you go in this fragile tundra environment the more permanent become the scars produced by human activities. Near the highest pass (Gyaco La, 5220 m) on our journey between Lhaze, west of Xigaze, and Tingri, we found evidence that the sparse tundra vegetation is cut up into sod brick and used for wind shelters and apparently even for fuel as a very poor peat substitute.

Going over this pass, which actually is the apex of a gently bulging peneplain, with some of the snow-covered Himalayan ranges off to the south, was quite an experience. Here we were, close to the 500 mb surface, with dancing heat, “schlieren,” rising into the air, an Assman psychrometer recording 9°C in beautiful sunshine that provided you with an instant sunburn, and cumulus humilis drifting lazily in a westerly breeze on top of a mixed layer that was at least 1000 m deep. We can vouch for the fact that on 12 June 1980 the plateau of Tibet acted as an enormous elevated heat source for the atmosphere. The low-tropospheric Tibetan heat low (see paper by Ye, pp. 14–19) was forming, but the summer monsoon south of the Himalayas had not yet set in. We began to appreciate the enormous thermal impact that this plateau must have on the general circulation of the atmosphere. Chen and Yan (1978) had found that extended snow cover in the Qinghai-Xizang region was followed by a delayed and weakened Indian summer monsoon. Reiter and Ding (1980a, b) pointed out that the Tibetan snow cover, in turn, might be related to North Atlantic sea surface temperature anomalies. No matter what the cause and what the
effect—those warm spring days of traveling across the roof of the world provided us with enough firsthand proof that here lay the cradle of the Indian monsoon.

We have mentioned that water resources might be one of the limiting factors in the economic development of Tibet. Yet we encountered plenty of water along the route of our tour. Many of the rivers we crossed should offer possibilities of hydroelectric power development. But, of course, the sparse population of Tibet does not suggest a need for such development, at least not at the present. Export of energy to other Chinese provinces over hill and dale hardly seems feasible. The glaciers of the Transhimalayas and of the Himalayas provide significant water flow to the Yarlung Zangbo (Brahmaputra) and some of its tributaries. We mentioned the Doilung Qu, at whose headwaters we explored the geothermal field of Yangbajain. Magnificent snow- and glacier-covered mountain ranges (the Nyainqentanglha Shan) with peaks in excess of 7000 m tower over the man-made geysers. Water temperatures in these springs can reach as high as 84°C only half a meter below the surface. H\textsubscript{2}S gas escapes through cracks and fissures in the rock—yet only a few hundred meters from this bustle of modern development and Chinese compounds one finds a wizened and weather-beaten Tibetan herdsman and his son, wrapped in sheepskin coats, tending a flock of sheep.

On our final journey across Tibet we left the Yarlung Zangbo Valley 50 or so kilometers west of Lhasa and wound our way up a breathtaking road, at first following a dry riverbed that, nevertheless, showed signs of irrigated agriculture, up into the clouds that shrouded the Kambala pass (4794 m). Breaking out of the drifting shrouds that a western disturbance had brought, a fantastic view opened up south of the pass. The enormous Yamzhog Yumco lake (678 km\textsuperscript{2}) spread below us, amidst barren mountains, curving in a wide arc to the southwest. We clicked off about 30 km following the shore of that arc, yet a look at our map convinced us that we had traveled only perhaps one-fifth of the extent of the lake. An outlet to the west that used to connect this valley with the Yarlung Zangbo had been blocked many years (someone mentioned 300 years) ago, creating this winding expanse of water. We passed through only two small settlements along its shores. The solitude and magnificence of the scene is hard to describe: no outboard motors, no hot dog vendors distracted from the beauty of one of the largest lakes of Tibet (Fig. 7).

About 30 km southwestward from this lake we underwent our first high-altitude test in crossing Karila Pass (5045 m) (Fig. 8). A heavily crevassed glacier, coming from the 7191 m Mt. Noijinkangsang, hangs to the north of the road, tapering into 20 m cliffs of ice down to as low as 5250 m (Fig. 9). We were told that this road is frequently blocked by avalanches that follow the route of the hanging glacier. The melting ice feeds the rushing Nyang Qu River, the largest tributary of the Yarlung Zangbo from the south, whose valley widened as we reached the irrigated—yet sand dune-spotted—fields of Gyantze. A fort built in defense against the Mongols overlooks the Tibetan settlement and temple compound (Figs. 10, 11). It was here that in 1903 a British military expedition, launched from India under Col. Francis Younghusband, overcame a Tibetan defense force that had retreated to the fort. According to our Tibetan guide, legend has it that a thousand outgunned and besieged Tibetans leaped to their deaths by jumping off the steep cliffs on which the castle stands, in preference to surrendering.

The Nyang Qu Valley between Gyantze and Xigaze (the seat of the Panchen Lama) is most likely the prize exhibit of irrigated agriculture in Tibet. Xigaze is a dry and dusty town amidst parched hillsides. Sand dunes along the hills of the Nyang Qu and the Yarlung Zangbo rivers, which join near this town, and a sandstorm kicked up by a small squall line
FIG. 19. Scenes along the excursion route: Strongly folded formations from the late Cretaceous (the Lingzizong formation overlying the Takena formation) in the Doilung Qu Valley; wheat fields in the foreground (upper left); stone mound on mountain pass between Xigaze and Lhaze (lower left); a limestone ridge with vertically thrusting spines near Tingri (above).

completed the impression of aridity. Indeed, water is a well-husbanded and respectfully treated commodity in these parts of the country, and the not-too-clean cistern in the old part of town seemed to be the hub of city life and gossip. The Zhaxilhunbo temple (Fig. 12) vies with the Potala in Lhasa (see cover photo) in terms of artistic interest, but not in fame and splendor. Of perhaps equal romantic attraction are the ruins of old fortifications that overlook the old city and that housed the district administration (Fig. 13). After several futile attempts Sven Hedin managed to visit Xigaze in 1907. His ink sketches prove that the fort still stood intact at that time. It appears that the destruction had occurred already before the Cultural Revolution, but we could not determine the causes.

A similar fate, perhaps more recently, befell the magnificent fort and temple complex that dominates the city of Xigar-Zhong (approximate spelling) near Tingri, which also served as a district administration seat (Fig. 14). The military camp that housed us overnight was at an altitude of 4600 m. After having crossed the Gyaco La pass (5220 m) as described earlier, our oxygen-starved bodies were about ready to quit. Lying down for a rest just made you listen to your heart pounding at a rate of 120 beats per minute. Sleep was impossible, because even after calming down by controlled breathing exercises every attempt to doze off ended in a choking sensation. In the morning at breakfast everyone in our party looked slightly peaked and ready to travel to lower elevations. Besides, the day before we lost one jeep, which went out of control and rolled twice on a treacherously sandy patch of road. The three occupants—our Chinese cooks, who were fit for any first-class restaurant—suffered contusions and concussions. The severest case was transferred back to Xigaze. The remaining two—we did not trust our eyes—were whipping up a memorable dinner, in spite of bruised and bandaged heads. They were not forced to do so, but they insisted that it was their responsibility.

The Pum Qu Valley, whose upper reaches exhibited beautiful examples of barchane development, opens widely near Tingri. A glimpse of Qomolangma Feng (Mt. Everest), unfortunately, was partly obscured by clouds, which, after the passage of an early morning squall that dumped some snow on the peaks around Xigar-Zhong, now indicated an easterly wind component aloft. Again our convoy wound its way up to an immense and barren-looking peneplain at the 5200 m level, the Yagru Xongla (Fig. 15). Some of the high Himalayan glaciers seemed to end right on this plain and one gained the euphoric impression (helped along by the lack of oxygen) that all you had to do was to walk up to one of them and start your conquest of Mt. Cho Oyu.

We were puzzled as to how we would make it across the Himalayas, especially since an untimely downpour caused by a westerly disturbance had washed away the road south of the main Himalayan range. The Bo Qu is one of several rivers that cuts through the world’s highest mountain system and provides egress to the south. We were told that we were the first party of travelers that would leave Tibet “peacefully” along such a southward route.

Until Nyalam (3810 m) the scenery looked familiar: high but barren mountainsides, holding a raging, glacier-fed river captive—and an occasional glimpse of glaciers hanging from some high peak that blocked a side valley. An annual precipitation of 600 mm and an annual mean temperature of 3–5°C are two characteristics of the harsh climate. The steep descent of the China-Nepal road immediately to the south of Nyalam brought rapid changes of scenery (Fig. 16). First
shrubs, then trees appeared, and before we knew it we were driving along forested mountainsides shrouded in rain clouds that were moving in from the south. As this change in vegetation occurred we came upon the landslide area that almost had prevented our exit from Tibet. As it turned out, we were only one day behind schedule, and the Tibetan road crew who waved at us smilingly had done wonders with pickaxes and shovels (Fig. 17). Not only had mud and boulders blocked the road in places, but at a couple of spots the road itself had sought a more convenient resting place deep down by the river. Those among us who were easily given to vertigo clutched the armrests of their seats, closed their eyes, and prayed to whatever saint was in charge on that day. The slippery trail was barely wide enough to accommodate a jeep, and I think our Toyota minibuses traveled along the abyss with at least one wheel in the air. It was still raining hard, and we were wondering whether the porous gravel and mud above the road would have enough capacity to soak up all this moisture before it would come sliding down on us.

We made it, and from here to Zham on the Nepalese border we saw a Tibet that we never knew existed. Evergreen broadleaf forest and bamboo thickets, dripping with 2000 mm of annual precipitation, enjoying 250 frost-free days a year, quickly made us forget the dusty roads of the Xizang plateau. A brand new, not quite finished tourist hotel received us as its first, inaugurating guests.

On 14 June, as we crossed Friendship Bridge spanning the Bo Qu to Nepal (Fig. 18), the Royal Nepalese border guards witnessed some emotional farewell scenes between a handful of Westerners, the first ones to embark on such an excursion, and the good friends they left behind.

Even though this excursion was billed as "scientific" (perhaps more so for a geologist than a meteorologist), we have to admit that scientific curiosity often was overwhelmed by the sheer beauty of the land (Fig. 19), by the unpolished openheartedness of its people (Fig. 20), by the feelings that creep up on you when you sit around a yak-dung fire, with stars so close above your head that you can almost touch them, listening to a medley of haunting Tibetan and Chinese songs, trying to remember the lyrics of "Old Man River" and "Swing Low, Sweet Chariot" as your offering to those flickering shadows around you. Nevertheless, there also was science—even good science. Since the Tibet Symposium in Beijing and the subsequent excursion to that mysterious country opened new doors for cooperation and established new channels for dialog, it was decided to let some of our Chinese friends speak out on this subject, instead of offering our own, less adequate views. The following papers (pp. 14–36) contain invited contributions from the People's Republic of China, to which the authors of this report owe a mountainous debt of gratitude.

Acknowledgments. E. R. Reiter gratefully acknowledges travel support for himself from the National Science Foundation, Office of International Programs, and from the U.S. Department of Energy under Contract DE-AS02-76EV01340.

References


Suyin, H., 1977: Lhasa, the Open City, Johnathan Cape Ltd., Great Britain.