A black outline map of California is centered on the page. The title "The California Geographer" is printed in a large, black, serif font, with the words stacked vertically and centered over the map. The word "The" is at the top, "California" is in the middle, and "Geographer" is at the bottom.

The California Geographer

Annual Publication of the
CALIFORNIA COUNCIL OF GEOGRAPHY TEACHERS

ROBERT A. KENNELLY, *Editor*

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THE CALIFORNIA GEOGRAPHER

The annual publication of the
CALIFORNIA COUNCIL OF GEOGRAPHY TEACHERS

ROBERT A. KENNELLY, *Editor*



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An outline map of the state of California, oriented vertically. The map is drawn with a simple black line. The title 'The California Geographer' is superimposed on the map. The word 'The' is in the upper left, 'California' is in the middle, and 'Geographer' is in the lower right. Three thin black lines point from the text to the map: one from 'The' to the northern coast, one from 'California' to the central coast, and one from 'Geographer' to the southern coast.

The California Geographer

This issue includes a group of essays contributed in honor of

JOHN E. KESSELI

by some of his former students

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Additional Articles were received from F. H. Bauer, Maurice Perret and Margery Saunders-Hellmannx. They could not be included at this time.

Statements and opinions in *The California Geographer* are the responsibility of the authors and do not necessarily reflect the views of the California Council of Geography Teachers.

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ANCIENT CHINA UNDER MODERN COMMUNISM: THE COMPARATIVE MORPHOLOGY OF PRE-COMMUNIST AND COMMUNIST SOCIETY*

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The consideration of Communist China presents to Americans a compound problem for which there seldom has been adequate material either of descriptive or analytical variety. There is a tremendous literature upon the Ancient China, and a not inconsiderable literature upon the contemporary China. What has been lacking, so far, is a comparative and interpretive literature, that strains out the common denominators and the elements of true difference, and that suggests how the present Communist China can have emerged so abruptly and so completely out of the ancient China.¹ The present discussion is not what might be termed basic research, since it sets forth little that is new to the literature of the two Chinas. It is, rather, a review of the ideas, themes, and workings of the two phases of Chinese society, in an attempt to suggest that the very recent past can be considered to have continuity in the evolution of a single stream of development.² These matters are geographically significant in that both the ancient and the Communist China occupy the same landscapes of the earth, deal with the same ethnic units, climatic regimes, natural resources, and agricultural problems. This discussion, then, reviews certain basic patterns of classical society in China, remarks on a variety of cultural processes, and notes the continuities and contrasts in the Communist China of today.

BASIC CULTURE COMPLEXES IN CLASSICAL CHINESE SOCIETY

Analysts of past Chinese culture have placed their primary emphasis upon one or another of several different complexes, according to their concerns. It would appear that no single complex bears the whole weight of the structure of Chinese society or forms the single cement that holds it together. I prefer to think in terms of a number of complexes, each significant in its own way, each of which forms a building block integrally supporting the whole structure. If too large a number of complexes are enumerated the duplicative interrelations between them become complicated; if too

* This is the text of the address presented at the Annual Banquet of the California Council of Geography Teachers, Northridge, Calif., May 6, 1961.

¹ For historic China, see the bibliography in K. S. Latourette, *The Chinese, Their History and Culture*, (New York, MacMillan, 3rd ed., 1959, and the extensive bibliographies in J. Needham, *Science and Civilization in China*, (Cambridge University Press, Vol. 1, 1954, Vol. 2, 1956, Vol. 3, 1959). For both historic and recent periods see bibliography in C. T. Hu, *China, Its People, Its Society, Its Culture*, (New Haven, HRAF Press, 1960), and for the most comprehensive bibliographies on recent China see the three biennial volumes edited by E. S. Kirby, *Contemporary China*, Hong Kong University Press, 1956, 1958, and 1960). The bibliography in G. B. Cressey, *Land of the 500 Million*, (New York, McGraw-Hill, 1955), covers the more distinctly geographic aspects up to the date of its publication.

² Where obviously useful, references will be supplied to sources of information upon particular subjects, but not every issue in an article of this sort can be documented without the supporting material becoming unwieldy.

few are itemized, the derivative applications become numerous and abstruse. In an effort to reach a middle ground, it seems possible to establish six such complexes that became the foundation stones on which classical Chinese society was built. These are:

1. The family (meaning, in this case, the larger family, often termed the extended family or the joint family), which includes more than one biological family, the latter sometimes called the conjugal, natural, or nuclear family,
2. The compact village settlement, not precisely distinguishing between the village and the town,
3. The walled city, as distinct from the village and the town in functional terms,
4. General social organization, involving elements of structure, stratification, regionalism, and function,
5. Egocentricity of the Chinese world view, sometimes labeled ethnocentrism, involving the definition of Chinese and non-Chinese, and,
6. The agrarian orientation of life, including the concept of the harmonics of nature and the relations of man to nature.³

Many might choose to add items to this basic list, but I believe these sufficient for the purposes of this paper, for such other complexes can be derivative of one of the above.

It is necessary to do more than list the building blocks: an examination follows as to the nature of each of the suggested complexes; although it makes no attempt to demonstrate all possible functional applications or derivatives. To considerable extent we cannot conceive of these complexes as fully operative in unchanged form from ancient time to the modern day, but we can conceive of them as the basic complexes around which, and upon which, the elaborate structure of eighteenth century Chinese society was built. Their relevance to Communist China will be reserved for a later section of this paper.

1. *The Family*.⁴ We cannot even guess what kind of family group was considered optimum by Peking Man, and we can do little more than guess, so far, as to the family group normally operative in Old Stone Age time as indicated by the living sites that have been partially explored by the archaeologist. But it is clear that long before Confucius codified the concept of the family in the sixth century B. C., the Chinese extended family was a functioning unit in social, economic and political terms. Though the smaller biological family has always been present in China, the larger family has been numerous and has been effective. Essentially, the family has been the basic economic unit of organization, whether

³ Many authors deal with this issue in variable terms. One of the best short statements is to be found in E. O. Reischauer and J. K. Fairbank, *East Asia, the Great Tradition*, (Boston, Houghton Mifflin, 1958) pp. 23-30. Material on all the culture complexes here listed can be found in Hu, *op. cit.* D. Bodde, *China's Cultural Tradition, What and Whither?* (New York, Rhinehart & Co., 1957), is the best brief source for notations on the Chinese view of nature.

⁴ In addition to Hu, *op. cit.*, and Bodde, *op. cit.*, see O. Lang, *Chinese Family and Society*, (New Haven, Yale University Press, 1946), M. J. Levy, Jr., *The Family Revolution in Modern China*, (Cambridge, Harvard University Press, 1949), C. K. Yang, *The Chinese Family in the Communist Revolution*, (distributed by Harvard University Press, Cambridge, 1959).

it be thought of as a production unit, as among the mass of the people, or as a control and management unit, as among the smaller numbers of controlling families. In classical terms the larger the family, the more effective was the economic unit. Plural wives to ensure sons, ancestor worship to strengthen family ties, wide scattering of family members in times of geographical and societal mobility, multiple patterns of economic endeavor to stabilize the economic status: these and other aspects all were features of an expanding society in times of economic and population growth. Infanticide, the disowning of family members, the giving away or selling away of children, the simple dying out of family lines, the forcible extermination of families, and the disruption of family life: all these and other aspects were features of a shrinking society in times of stress and trouble.

Both types of phenomena were recurrent throughout most of Chinese social history, dependent upon the upward or downward spiral of Chinese society at the particular time. Inasmuch as the nineteenth and early twentieth centuries were periods of a downward spiral, the Occident is more familiar with such aspects as infanticide, the selling of children into "slavery," and the disruption of family structure. It is obvious that in times of stress the weakening of family strength was accompanied by features making for decimation of families, and the literature is full of the theme, for such things happened among the masses of Chinese families. It is less well known that among the ruling families, sometimes now termed the gentry, the degree of continuity and the maintenance of family strength has been very marked, and that the features of decline so commonly remarked upon for all China were operative to a minimal degree only.⁵ It would appear that, in numerical terms, hundreds of families were able to maintain themselves in secure positions for more than 2,000 years, if not much longer. The relative number of such gentry families decreased about 900 A. D., and a new level of middle class gentry families came into existence to broaden the basis of the ruling family sector. However, significant numbers of the earlier families maintained themselves until very recently, and large numbers of families measured their continuity in centuries.

The family concept lay behind the concept of government as the political state evolved, in that a good father was a good ruler and a good son was a good citizen. In point of hard fact one can carry this concept too far in applying it to the operation of the classical Chinese state, but there prevailed the general idea that the Chinese state was a government of men, not of laws, and to the degree that the concept was operative it functioned regardless of the going form of the state. The concept operated in the tribal "state," functioned in the feudal state, continued operative in the national state, and the concept certainly can be seen operative in the Communist state in which Comrade Mao is visualized as the good father of his people. The traditional Chinese political state is normally described as authoritarian, a term as descriptive of earliest China as of Communist China.

⁵ W. Eberhard, *Conquerors and Rulers, Social Forces in Medieval China*, (Leiden, E. J. Brill, 1952), and "The Leading Families of Ancient Tun-huang," *Sinologica*, Vol. 4, 1956, pp. 209-232.

It has been commonly asserted that the Chinese concept of the larger operative family has been both the basic building stone and the strongest bulwark of Chinese society that would withstand all forms of onslaught. There are other pertinent elements in the functioning of the family, and the author has condensed a major subject into simple terms, but the significance of the family in classical China was primary, no matter how the pattern was elaborated. The family became the key element in three other basic culture complexes in an interlocking series, namely, village settlement, general social organization, and the agrarian orientation of life.

2. *The Compact Village*.⁶ The compact village as the operational base of a group of families can be viewed as an organized extension of the family in that it is a larger economic grouping able to encompass a greater variety of economic production in greater volume, and in that it is a group large enough to stand alone in a regional landscape exposed to competing groups and patterns of culture. In the sense of a regional unit occupying a given sector of the landscape, it often functioned as did the family, with give and take of labor, produce, strength, resources, refuge, protection, and initiative. It often has been said that there was a high degree of cooperative democracy in Chinese village life. In that many villages in earlier times were composed of related families, there often was such democracy and cooperation, and where a village was composed of unrelated families there often was decision making in common by the elders of the families, but such democracy never approached the ideal referred to in the American town meeting of our earlier New England days.

In most portions of China the compact village was the key settlement form; only in a few regions for specific situations were other settlement forms employed. But always the village was the center of the mass of the population, from neolithic sites to modern villages, whereas the active and essential control over the life of the village was situated outside the village and apart from it. The village never had legal status in the administration of China, and political administration has been imposed from above and outside. The palace, the great house, the magistrate's yamen, sometimes even the headman's establishment sat apart from, and above, the compact village as a specific settlement form, and the occupants thereof lived apart from the mass of the people and rarely were truly of them. The village seldom was the place wherein originated the ideas, the technologies, the codified norms, or the ideal mores of Chinese culture, but the village was the place where these cultural norms came to rest in the stable patterns of Chinese society as we have known them historically.

The earliest villages undoubtedly held customary rights to the plant, animal, and mineral products of the land, and in time the village came to have vested customary rights to the use of land and to the local lands themselves. This is a normal case of territoriality and its evolution, but to the ruler the people went with the land as paired resources even though the

⁶ Bodde, *op. cit.*, C. K. Yang, *A Chinese Village in Early Communist Transition*, (distributed by Harvard University Press, Cambridge, 1959), H. T. Fei, *Peasant Life in China*, (London, George Routledge and Sons, 1939), and see S. D. Chang, "Some aspects of the Urban Geography of the Chinese Hsien Capital," *Annals, Assoc. Amer. Geog.* Vol. 51, 1961, pp. 23-45, but particularly pages 39-43.

power to separate one from the other was implicit. The evolution of the national state brought with it the concept of private ownership patterns, applicable to plants-lands and to animals, and drew sharper lines than had older customary ownership concepts. To the village population these new concepts did not alter the local regionalism of the village as related to its surrounding lands. The concept of private ownership had lesser regional implications for the upper level family in that such a family was not restricted to a single village, and in time the gentry families associated themselves to a region but were apart from any village within the region. It is here that the town and the city play their role in Chinese society. The city, particularly, was the seat of the gentry extended family, though some of its biological family units normally were distributed both in the villages and in other towns and cities. Because the gentry extended family often had biological family units engaged in all kinds of economic and political activity, it ranged widely, dependent upon villagers but not of them.

Chinese village life has often been extolled as the good life. In good times village life has been secure and adequate in terms of food, shelter, and the provision of livelihood necessities. But village life in China has been dull, intellectually barren, and less rich and satisfying than most authorities suggest, since the generalizations about Chinese culture are drawn from cities and towns. Dull and barren in the best periods, village life has been exceedingly stagnant, torpid, and stupefying in those periods when economic privation has made even simple subsistence a hazardous problem.

The reputed self sufficiency of the village, its autonomy so long as things went well, its relations to the city, its relations to territory and region, and its place in the scheme of Chinese society became stabilized in time and structure. The mass of the Chinese became villagers and China became a mass of villages, functioning cells in a steadily expanding society. In the general sense, with little exception, China spread where stable village life could spread. Even the exception is not real, for in Szechwan, Kwiechow, and Yunan villages were present, village life was operative within the same broad patterns, and the same general terms applied—it was only that a rural population lived scattered out on the landscape around their villages. In such areas as Tibet, the Mongolias, and Turkestan, the sedentary agrarian village-local regional lands complex was not possible, and here Chinese hegemony normally was dependent upon military control of territory and was, therefore, impermanent. In southern and western China the very process of becoming Chinese involved local populations giving up their regional mobility, settling in permanent villages, and adopting practices of sedentary agriculture on lands lying around the villages.

The expansion of village life was a function of an expanding society and economy. The decline of village life and the accumulation of poor, landless, and unemployed villagers was a function of a declining economy and society. The inroads of occidental manufacturing upon Chinese village handicrafts, the rise in land tenancy, and the declining level of living of the nineteenth and early twentieth centuries were periodic aspects of a declining spiral; their greater intensity in the last century brought the decline to a more critical state than had been the case in many earlier periods.

The sheer growth of Chinese population in recent centuries involved a greater degree of crisis than had a similar decline in earlier centuries for a lesser population.

3. *The Walled City.*⁷ The only real word for city, as a distinct class of settlement in China, is the word *Ch'eng*, meaning wall. Walls were built across-country as boundaries, and around villages in old north China, but the appropriation of the word *Ch'eng* for city denotes the significance of fortification for key settlements at an early date. Walled cities in North China, at least, pre-date the historic record, but the archaeologist has not yet unravelled much of the earlier story. In early historic time the city became synonymous with the following: seat of political and military power; palace-residence of the holder of power; seat of wealth and base of the regional tax collector; center for skilled handicraftsmen who depended upon the wealthy both for patronage and protection; residence seat of scholars, astrologers, priests, and administrators of the surrounding area; residence of a certain number of what may be termed "service personnel"; seat of merchant traders; the residence base of a certain population for whom no specific function can be applied at present; chief market for produce and trade goods of the surrounding countryside; center for the collection of tribute, and ultimate refuge of at least a portion of the loyal rural population of the countryside in time of invasion. Perhaps there were other functions also. As territorial expansion took place certain advance sites were built into cities, for the function of the city as the seat of political, military, administrative, and taxing power seems the dominant function once the formal designation of places as cities began to occur.

No full discussion of the city can be given here, since too little is really known about the full role of the Chinese city. We do not even know just who lived in Chinese cities in early time, how they got there, and what their status in society was. However, it is clear that once cities came into being in China they became not only the centers of political, military, and economic power, but the real functional heart of Chinese culture. It was the cities that generated the culture patterns, set the styles and the norms, prescribed the definitions, called the changes, and served as the agencies of control of the Chinese landscape, be it local county, general region, frontier zone, or nation as a whole. The significance of the city, for this paper, is in its function as originator of culture and controller of the countryside, and here it was that the ruling families had their residence and base of operations. In the decentralization of historic China, the regional city had a very real role as the center of a "little China."

⁷ There is extremely little literature of real significance on the origin, nature, and role of the historic Chinese city. G. T. Trewartha studied Chinese cities, but did not deal with the critical cultural issues in his two papers "Chinese Cities: Numbers and Distribution," *Annals, Assoc. Amer. Geog.*, Vol. 41, 1951, pp. 331-347, and "Chinese Cities: Origins and Functions", *Annals, Assoc. Amer. Geog.*, Vol. 42, 1952, pp. 69-93. R. Murphey, "The City as a Center of Change; Western Europe and China," *Annals, Assoc. Amer. Geog.*, Vol. 44, 1954, pp. 349-362, suggests many of the problems. Chang, *op. cit.*, gets close to the heart of the problem of the place of the city in Chinese society. W. Eberhard, "Data on the Structure of the Chinese City in the Pre-Industrial Period," *Economic Development and Cultural Change*, Vol. 4, 1956, pp. 235-268, in a penetrating study has some tentative conclusions of real value, and asks many questions that need answers.

4. *Social Organization*.⁸ The theme that the poor boy can become president, that a Henry Ford can come from a humble home, that Abraham Lincoln could learn to read by firelight in a log cabin, that you and I may acquire Cadillacs, great homes, and status in our communities is a favorite in American life. Perhaps here it has more often come to pass than elsewhere in the world, which makes it such a significant attribute of American life. Chinese culture possesses somewhat the same optimistic theme, and the leaders of China have always played upon the theme for what it has been worth. That it undoubtedly operated over the long centuries of Chinese history gave reality to the theme, but the relative frequency of the individual rise has been far less than popularly believed and far less than in American life. It certainly is true that Chinese society never developed a highly stratified social organization with inherited status patterns such as became characteristic of Hindu Indian society, but the extended family, when secure in position, gave to its younger generations status and power that were almost as effective as inherited patterns. It is true also that in developing the national political state, both formalized slavery and formalized nobility were done away with. Both these elements of social structure had died out by the start of the Christian Era among the Chinese themselves, though such alien ruling groups as the Tobas, the Mongols, and the Manchus brought to their controls of China a limited nobility structure. The abolition of slavery and nobility evolved slowly with the maturing of the legal institutions of private landownership and its patterns of transfer. Tenancy and landlordism, in a sense, in time replaced slavery and nobility as institutional elements around the land system. The gradual identification of the wielders of political power with government bureaucracy and with the landlords solidified the legal institutional framework; the opposite identification of the small landowner, the artisan, and the tenant with the peasantry was a parallel development in the slow growth of Chinese social structure. The preservation of personal "slavery" as a technique of self preservation did continue until the twentieth century. In times of famine poor families often gave away a child to people able to maintain it and sometimes "sold" the child, the price received aiding the seller in maintaining his own life. This is something quite apart from formalized slavery.

The Chinese patterns of social organization must commonly have recognized four broad classes, those of scholar, farmer, artisan, and merchant. These are essentially functional in nature, and since they involved no formal hereditary controls, this simple structuring permitted the rise and fall, or simple shift, of individual families. However, this simple consideration disguises the very nature of Chinese social structuring. A farmer was an agrarian rural peasant while a scholar was an urban resident associated with political controls. Farmers and artisans were closely related in that the extended peasant family normally contained both. In the same way merchants and scholars often were closely related in that the gentry families often included both kinds of members. The rise of merchant classes out of artisanry, with conflict in social status-making, is an old theme in Chinese history.

⁸ Hu, *op. cit.*, Lang, *op. cit.*, Bodde, *op. cit.*

This coupling of agriculture and artisanry, and of scholar-official and merchant developed a bi-polar status in the broad social framework of Chinese society, the rural-agrarian and the urban-intellectual-merchant-official. These two groups now are more commonly labeled the peasantry and the gentry. The fiction, and the reality, of individual and family movement from one to the other group occurred sufficiently often that the two broad groups never became totally separated. Periods of societal decline normally were marked by the sinking of some families from the upper level into obscurity, and by the rise of new families into the upper level, whereas periods of societal expansion normally were marked by the recruitment of new individuals and new families into the upper levels. Particularly after the civil service patterns matured and China went through periodic expansions of the state, this recruitment served to maintain the ranks of the upper levels of society. It also afforded an occasional peasant boy, who by good fortune secured an education, entry into the ranks of officialdom, and in such case his whole family shared his good fortune. This statement somewhat simplifies the long social history of China, but its basic features are significantly operative. As an old Chinese proverb has it: "The ox plows the field, but the horse eats the grain."

The Chinese have long spoken in terms of the *hsiao jen*, the little people of the rural agrarian scene, and the *chun tzu*, the gentleman who formed the urban upper classes. The whole Confucian pattern of life was framed in terms of the commoner and the aristocrat, the governed and the governing, the agrarian and the urban, the peasantry and the gentry. This bi-polarity sometimes became a dichotomy which penetrated and affected village life as well as the broad structure of society as a whole.

Early Chinese social organization utilized the clan and has never entirely lost this element of social structure. Once the national state developed, the role of the clan declined, in north China far more than in south China. As an economic unit larger than the family, however, the clan remained an operative unit in life. As a social form amenable to political action, the clan organization was frequently revived during periods of disturbance, political decline, rebellion, and the reconstruction of patterns of stability.

Less formal elements of organization, in the strict sense, were the guilds, the regional groupings, the provincial fraternity, the counting of district and county home status. Into the overall framework of social organization the scholar class eventually fitted the concept of the examinations and the civil service rankings. There were many other elements of social organization that were developed for the stabilizing of life in general and life for the individual, down to such things as the beggars' guild. That the soldier was never given status in China perhaps was by common consent of all the established general classes—he could but prey upon the little people, tax the merchant, and deprive the scholar of power.

Throughout Chinese social organization there runs a strong pragmatic thread of utilitarianism—class patterns were developed and maintained which were mutually helpful elements to large numbers of people. There was give and take, transfer of status, rise and fall of individuals and families. Alien groups brought in new elements when rising to power, non-

Chinese became Chinese by the acceptance of general standards, Chinese initiative reduced threatening elements when it could. Chinese social structure never became totally static or fixed in immutable patterns, but its generally accepted patterns have been one of the very definitions of who was a Chinese, and, to this degree, social structure was one of the basic building blocks of Chinese society.

5. *Chinese Egocentricity.*⁹ A Chinese proverb, "Within the four seas all men are brothers," has often been quoted as a sort of peaceful ideal for world society. The proverb did not originate in an international context, and the four seas referred to cannot be equated, in reality, to oceans at the ends of the planet earth. The proverb contains an implicit egocentricity which is manifest throughout Chinese history, for its original meaning suggested that even Chinese scoundrels were Chinese. All peoples of the earth, as unit population based on some kind of grouping criteria, distinguish between "we" and "they," and the criteria vary tremendously, often involving some element of physical human biology. Many peoples express some degree of superiority over other peoples—Americans are often disliked around the world for the superiority they exude. In Chinese terms the "we" is best equated historically with the concept "civilized," and the "they" with the concept "barbarian." These terms are thus not a reference to human biology in any sense, but a definition of Chineseness. Those people who think, act, feel, believe, revere, disdain, admire, dislike, and assume as Chinese do *are* Chinese; those who do not *are* barbarians. Not only is a type of reaction involved, but implicit in it is a quality reaction. To be Chinese is superior to being non-Chinese. The definition of what constitutes the accepted sum-criteria of Chineseness at any particular date in history changes, but there remains a group concept of type and quality. The earliest Chinese did not write, their ancestor worship was ill-prescribed, their agriculture was primitive, their food economy was very simple, and their domestic architecture was crude, but there was a beginning concept present even then. In the alteration of the criteria themselves in more recent centuries the elements that went into the type definition altered, but the essential quality has not altered.

Throughout Chinese history the leadership of the Chinese has striven to keep before the population an acceptable concept of what constitutes Chineseness. In that this has been accomplished, China has absorbed her conquerors—historically they all became Chinese, and few Chinese totally submerged themselves in other cultures. Within the four seas all men are brothers, are civilized, and are Chinese; outside the four seas all men are unrelated, are barbarian, and are not Chinese; this is a far more realistic interpretation of the Chinese proverb than that holding it a pacifist ideal for world society. China as the center of the civilized world has long been one of the ideas implicit in Chineseness. All non-Chinese should pay respect and homage to the Chinese; if they can be induced to admit their inferior status and pay tribute, so much the more proper.

The above attitudes have not been very fully expressed in the last two centuries during which the European world has displayed its own criteria

⁹ See Hu, *op. cit.*, pp. 502-506. This complex has seldom been described explicitly, but is implicit in many kinds of remarks by Chinese; it often has been glossed over in occidental writing.

of egocentric superiority, but they have not disappeared. In the high periods of Chinese history they clearly have been expressed. There has been a tolerance in their expression, of course, and when other peoples peacefully adopted the Chinese way they peacefully became Chinese. This has been one element in the geographical expansion of China—the peaceful expansion of China by the barbarian adoption of the Chinese way. But when the adoption of the Chinese way has been resisted by the barbarians, then something akin to manifest destiny and military and political imperialism has come to the fore among the Chinese to the end, that, during the high periods, Chinese power expressed itself in the whole of eastern Asia.

China and Chineseness could not spread where the agrarian village could not go, that is the dry or cold interior heart of Asia; it could not spread to those peoples yet too simple in culture to accept the Chinese way, the simple tribal shifting cultivators of southeast Asia; it could not succeed among those who emigrated rather than accept, such as the Thai, the Lao, the Miao, the Burmans, and others of southeast Asia. The Chinese always have recognized that there are those outer realms of the world to which the Chinese way was not fully applicable, but these must remain to some degree barbarian.

The egocentricity has been one of the things that has kept a living China operating for a longer period than any other single society on the face of our earth. It has been an intangible cement which has defined Chineseness, has altered the specifics of the definition during changing times and changing technology, but has remained essentially a unified concept throughout.

6. *Agrarian Orientation*.¹⁰ Chinese society has been one rooted in the productive soil of local regions, one given to a permanent concern for the relation of man to a specific place. It shows itself in the way in which a Chinese village farmer stays with his land if he possibly can, and is shown in the way in which a Chinese, removed thousands of miles and born generations later, will still refer to his homeplace as a specific locality somewhere in old China. In its most obvious phase this orientation has been that of the agricultural villager whose primary concern is the growing of crops on the good earth.

Historically the earliest Chinese crop growers were shifting cultivators who also engaged in hunting animals and birds and in fishing in local waters. The agrarian orientation became stronger, however, as sedentary village agriculture replaced shifting cultivation and mobile living, to the degree that the pastoral orientation of following animals about became an early synonym for barbarianism. This orientation grew stronger with the evolution of the legal institutions of private landownership, and it grew into an orientation that viewed agricultural land as the only economic good. The great debates at the start of the Christian Era sharpened the agrarian orientation, and relegated transportation, trade, mining, and manufacturing to a secondary position.¹¹ During the whole of the Christian Era this orien-

¹⁰ This subject has been discussed by many different authors and most of the literature dealing with Chinese economy stresses it. Cressey *op. cit.* deals effectively with the specifics.

¹¹ See E. M. Gale, *Discourses on Salt and Iron*, (Leiden, Brill. 1931).

tation remained strong, so strong that the introduction of nineteenth century alien features such as railroads, foreign-style buildings, and factories were thought to be destructive of the agrarian harmonics of the Chinese landscape.

So long as the Chinese were few in the midst of a great and extensive landscape this agrarian orientation supplied all of them most adequately with a living. During the growing periods of Chinese society there was land enough for all who came into the Chinese world. The leadership elements of Chinese society helped maintain this orientation, for it made for rural stability and prosperity. The agrarian orientation fitted the family system, the rural village system, the broad patterns of social organization, and it formed the contrast with the lesser economies of the surrounding barbarians of all kinds. The leadership elements themselves maintained relations with local rural communities and landscapes, they kept their identifications with place and with the land, and they kept the major functioning cultural elements of Chinese society in tune with an agrarian orientation. The good emperor annually offered sacrifices on behalf of agriculture at the Temple of Agriculture and officiated at the ceremonial spring plowing which opened the agricultural year. This steadfast view of the land by 1950, produced more than one hundred million families who still thought in terms of the land, the agricultural life, and the good earth on which it was founded.

THE CYCLIC PATTERNS OF CHINESE HISTORY

Though Chinese society has been continuously operative for some four thousand years, its vigor has not been sustained at the same high level during the whole period. There have been periods of decline and resurgence, of privation and prosperity, of weakness and strength, of turbulence and peace. To some the waxing and waning become inevitable and cyclic, to others they are but the repetition of events in a society long governed by a single basic set of concepts. The Communist viewpoint sees different methods of the ruler exploiting the masses, either more or less brutally, from the ancient age of primitive communism, through clan society and feudalism, into the modern era of capitalism controlled by alien interests. The non-Communist economic historian recognizes those periods of upward spiralling economic growth during which political, social, and economic institutions, and their administration, were in balance, and those periods of downward spiralling, economic decline in which institutions and their administrations were out of balance. The ascribing of causes to the various directional currents of Chinese history takes one pattern under the Communist viewpoint, whereas non-Communist scholars have not fully studied the periodicity of Chinese history with an eye to ascribing causes.¹² The dating of cycles, the prescribing of descriptive terms for the periods, and the causes of periodicity are not the object of this section, but the recognition that there have been such periodic ups and downs is important to the balance of this paper.

From at least early Chou dynasty time, about the eleventh century B. C., down to the early nineteenth century one can suggest that the basic tenets of Chinese culture were not really altered. Many institutions of

¹² Eberhard, *op. cit.* *Conquerors and Rulers*, has reviewed Communist theories, pp. 45-51.

society have changed, and the population has grown, but the fundamental concepts of China, and Chinese culture, have remained those of the patterns suggested above in the six basic complexes. During an ascending spiral people lived well, the area occupied by Chinese expanded, and the population increased. During a descending spiral people lived less well, sometimes the area contracted, and population stabilized or even contracted. Replacement of a deteriorated, inefficient, corrupt dynasty and its civil and military bureaucracy by a new dynasty with a reformed bureaucracy normally was accompanied by a period of turbulence, indecisive leadership, and seeming short or long term chaos. Replacement by a new dynasty which initiated a new upward spiral brought in some new institutions and technologies, but is chiefly operated to restore the efficiencies and the stable patterns of the past. The new dynasty pruned back divergent currents, redressed the balance, maintained the basic institutions of the past, and returned to the agrarian orientation.

Such continuity of family-operated, agrarian-orientated, village-based, city-controlled civilized Chinese society was possible so long as the agricultural landscape possessed reserves of land within the core area or upon its margins which could be utilized by the established order. It is now recognized that in the early nineteenth century the Chinese were running out of agricultural landscapes amenable to their system. The late nineteenth and early twentieth century expansion into Manchuria removed the pressure temporarily for the people of north China; the late eighteenth, nineteenth, and twentieth century migration of southern China into southeast Asia, to lesser degree, accomplished the same thing. But by the twentieth century the cyclic rise and fall of an agrarian society was deep in its last possible decline—no governmental restoration of a dynasty, a party, a bureaucracy, or a system could restore expanding economic growth and peaceful stability to a society whose population had simply outgrown its area of operation unless major changes were to be made in the whole functional structure of society. Such changes necessarily involved altering the fundamental nature of the basic building blocks upon which Chinese culture was constructed and only a group with a truly revolutionary approach could hope to succeed in its prospective program.

This is not the place in which to argue whether the Nationalist Government, a Democratic League, or a new Emperor could have established a successful government in control of all China, for the people of China, as a sum of cultural attitudes, neither realized the need for, nor desired, a change in the basic patterns of Chinese culture. The Nationalist Government tried to work chiefly within the framework of the past; groups and factions opposed to that government advocated lesser or greater degrees of basic change. The Communist Party formulated the successful program by which the support of the masses was won for a program of reform within the patterns of the past. When support was achieved, the Communists proceeded to changes of such a drastic nature that they seemed to break totally with the past. The issue of Communists *vs.* Nationalists, to the Communists, has ended in terms of the old Chinese proverb: "Conquerors are Kings, the Beaten are Bandits." The burden of this paper is that the Communists have not broken totally with the past, but that they have in-

roduced a series of new institutions which can be operated in ways practically compatible with the patterns of the past.

THE CHINESE COMMUNIST CONCEPTUAL PROGRAM

No attempt will here be made to state precisely what the Chinese Communist Party believed or to justify what they advocated or did on any precise date. Marxist philosophy as to strategy and tactics is such as to make this attempt both unprofitable and unnecessary. For all the pronouncements by the Marxian school on the nature of Chinese society and economy and the best way to revolutionize it, there are many variations and contradictions in the literature on the subject. However, it is clear that by 1945 the Chinese Communist leadership was committed to the concept that China, in a world permanently altered by the Industrial Revolution, could not remain the family-controlled, village dwelling, decentralized, agrarian-oriented society it had been. An industrial revolution in China was an urgent and absolute must, and the mobilization of economic resources to underwrite that revolution primarily had to come from within China itself. This demanded an end to the economic system wherein family investment in land still was the primary pattern of domestic economic growth; it also demanded a degree of authoritarian centralization in the administration of economic resources such as China had never had. Two major obstacles stood in the way of the whole Chinese Communist program: (1) the very traditional, localized, agrarian cultural orientation of the Chinese peasantry, and (2) the restrictive influence of non-Chinese in Chinese economic and political affairs. The Chinese Communist program, therefore, set out to destroy those aspects of traditional Chinese cultural institutions that would hinder the evolution of centralized control of economic growth along the lines of an industrial society and to destroy non-Chinese influence and power which could hinder carrying out such revolutionary program as might eventuate in the long run.

Whether or not the National Government of China could have, in the long run, produced the necessary revolution within a sufficiently short time to lift the level of Chinese living need not be argued, since they lost the support of the masses of Chinese requisite to carrying on any program. Though the Russian revolution had been born in the city and was carried to the countryside, the Chinese Communist Party eventually secured the support of the Chinese peasantry in rural areas, after which the Party could take over the cities. The Chinese Communist program, therefore, began with land reform and stayed with it, in the traditional sense, until it had achieved control of the country and the population; after this the revolution could take its originally intended course. To keep the support of the masses of the peasantry, or at least to keep them sufficiently quiet so that wholesale rebellion could not occur, the program repeatedly had to shift its orientation temporarily, even in directions that might appear to the outside world as un-Marxian.¹³

¹³ See the various Chinese documents on agrarian policy reproduced in K. C. Chao, *Agrarian Policies of Mainland China: A Documentary Study 1946-1956* (Distributed by Harvard University Press, Cambridge, 1957), and see Y. L. Wu, *An Economic Survey of Communist China*, (New York, Bookman Associates, 1956), and Hu, *op. cit.*, for general statements, and Yang, reference cited in footnote 6, for specific data on one village.

The Chinese Communist Party also had to build new cultural, economic, and administrative institutions to replace those features of traditional China that were to be destroyed. So far as possible, traditional inclinations, tendencies, abilities, and habits needed to be utilized in order to make working programs appear familiar, acceptable, and Chinese. That these appeared to the outside world to involve un-Marxian trends, contradictions, reversal of direction, even idiotic activities, was of no consequence, so long as they kept the Chinese populace busy, fully occupied, and at least amenable to direction. A basic strategy, exploited tactically, was to utilize the energies and weight of "opinion" of the lower sectors of the peasantry to further the program of the Party, this weight in itself constituting the opposition to the literate, articulate, uncooperative middle and upper classes, for the lower classes could be counted upon to support demands against the groups above them as they repeatedly had done in past historic time.

THE COMMUNIST PROGRAM IN OPERATION

It is not the purpose of this article to review the whole working program of the Chinese Communist Party. Rather, the purpose is to examine that program in terms of the basic and fundamental features of Chinese culture that have been utilized by the Chinese Communist Party in its program of revolution in China. A re-examination of the previously listed six basic culture complexes is therefore required.

1. *The Family*.¹⁴ Modernization and reform of the traditional family structure began slowly around 1900 and moved forward during the first half of the present century totally unrelated to the Chinese Communist program, but the movement had achieved little real progress in the rural countryside by 1950. The Chinese Communist program has retained the biological family as a basic social institution but has worked to destroy the political, economic, and cultural patterns surrounding the traditional extended family and its subordinate kinship relations as institutions. This has meant temporary excessive freedom of divorce, temporary separation of husbands, wives, children, and relatives, the encouragement of loyalty to the party and to the state in opposition to loyalty to family members. There is historic precedent for persons to inform against relatives and the Communist Party exploited this old "duty to the state." Sufficient cases of forceful disciplinary punishment of violation of the Marriage Law of 1950 have been carried out so that the basic institutional patterns around the traditional family have been broken, though by 1961 not every vestige of traditional tendencies has been eradicated. The courts continue to handle large numbers of cases of domestic disharmony in which traditional practices become the center of dispute, this being one of the major fields of civil litigation encouraged by the Communist Party. Catering to the position of women in society and giving them freedom equal to men has brought forth a strong degree of support from the women of China, and most of the litigation around domestic disharmony has been initiated by women.

¹⁴ Hu, *op. cit.*, Yang, reference cited in footnote 4, J. Y. Fan "Why We Have Abolished the Feudal Patriarchal Family System," *Peking Review*, Vol. 3, No. 10 March 8, 1960, pp. 9-12, and R. S. Kwan "The Commune, the Family, and the Emancipation of Women," in E. S. Kirby, *Contemporary China*, Vol. 3, 1958-1959 (1960), pp. 146-151.

The growing secularization of the Chinese family has had tremendous repercussions. The increase in the labor force has been notable, along with enormously increased mobility of family members as persons. The dissolution of family ties has rendered individuals and biological family units relatively easily amenable to state policy decisions since decreased loyalties and vanishing intra-family independence renders members of the family far more vulnerable than they were under older patterns. These are both religious and social residues of non-acceptance of the new patterns, and economic pressures hinder the full secularization of the family. Though the power and the strength of the traditional family has been broken, the complete disappearance of traditional elements of the complex is dependent upon the evolution of significantly new and sound ideological and social elements of family institutionalism. Here the Communist program has used such slogans as "democratic, harmonious, and united new family" involving "mutual affection and mutual respect," but the vagueness of social direction given by the Communist Party leaves the future evolution of new family institutions up to spontaneous processes and influences. By 1961 these had shown little real development in China, and the Communist Party cannot count their victory totally complete until stable new patterns evolve. Despite what happens to China in the future, however, it is clear that the full institutionalism of the traditional Chinese family will never return and that traditional family economics is a thing of the past.

2. *The Village*.¹⁵ A populous society that continues to grow in numbers but to reside within the same geographical area cannot abolish the compact grouping of residence patterns, and as dormitories or bedroom settlements, village-like and town-like settlement forms can only increase in number in China. The trend toward increased urbanization can turn old villages into towns, cities, and metropolitan areas, and this is happening at an increasing rate in China, but the village-like compact settlement form remains the most numerous feature of settlement geography in China. The introduction of the Commune is affecting the living habits of the Chinese population, in that community kitchens and dining rooms, points of population concentration during the day, work sites, centers of recreation, and centers of incarceration of recalcitrants are bringing change to the physical movement and location of persons.¹⁶ The reported barracks of the Commune are missing, still, from most of the twenty-odd thousand rural Commune units, but they may well increase in number, whereas relaxation in the early tightness of person-regimentation within the Commune, as a tactical maneuver, may well counter the influence of the barracks.

On the other hand, the functional operation of the traditional village has been destroyed by the Chinese Communist Party. The self-contained,

¹⁵ See Yang, reference cited in footnote 6, T. J. Hughes and D. E. T. Luard, *The Economic Development of Communist China, 1949-1958*, (New York, Oxford University Press, 1959), G. Hudson, A. V. Sherman, and A. Zuberman, *The Chinese Communes*, (distributed by Institute of Pacific Relations, New York, 1960), and K. C. Chao, "The Organization and Function of the People's Communes," in E. S. Kirby, *op. cit.* Vol. 3, pp. 131-145.

¹⁶ N. T. Chuan, "How Commune Dining Rooms Serve the Peasants," *Peking Review*, Vol. 3, No. 2, Jan. 12, 1960, pp. 16-17, is a sample of numerous short notes on the subject.

self-directed, independent cell-like autonomy of the village is gone in terms of its past operation. The centralization of administrative control, through membership in the Party, the steady transference of "cadres," the greater accessibility through transportation, and the immediacy of radio communication have destroyed both distance and time relationships for the village. The publication of disciplinary or commendatory action throughout China by the press, radio, and the "bamboo telegraph" has obliterated the isolation and independence of compact settlement groups. The incorporation of villages into integrated administrative units such as the Commune, the Agricultural Cooperative Farm, the Handicraft Cooperative, and other units under collectivization has destroyed the autonomy of village communities. It would thus seem that the Chinese Communist Party has destroyed the functionalism of another of the basic cultural complexes of Chinese society.

However, it is an old axiom that the Chinese prefer to be members of a group, and that they shun solitary living. The whole Communist program of collectivization has played hard upon this theme and upon the themes of cooperative action, democratic decision-making, and group activity. The early creation of mutual aid teams preserved the cooperative activity of the traditional village, and in the further collectivization of agriculture, handicraft, industry, and transport, every effort has been made to stress the group aspects of each form of activity. The more recent stressing of community dining rooms has made for social contact, group recreation, and group performance. The creation of a whole battery of organizations aimed at maintaining group solidarity has tried to capitalize upon the traditional pattern of close social contact. This is actually a program to marshal the labor forces into more manageable units, but it also is an effort to retain the social values of group activity inherent in Chinese society.

It would appear, therefore, that the Chinese Communist Party has tried to do two things with the traditional village community.¹⁷ First has been the aim of destroying the cell-like autonomy of the community which enabled one Chinese village to carry on its own little-world life unconcerned about what took place in areas round about. Second has been the aim of reorganizing the economic functioning of the village community as a group of independent families into a highly integrated, centrally controlled production unit whose resources and output could be more easily utilized and tapped and whose consumption patterns could be more efficiently controlled. To a very considerable extent the patterns of reorganization are those which, at least in theory, make for efficiency in the accumulation of capital resources and labor required in industrialization. The sheer problem of collecting production of commodities and taxes from more than 100,000,000 family units in the rural sector was too great, when the whole collecting system had been poorly developed, for centralized collection and when transportation was not effective to the same end. The similar problem of accumulating savings and other forms of capital resources to finance industrialization was equally insurmountable under the

¹⁷Hudson, Sherman, and Zauberman, *op. cit.*, C. M. Li, *Economic Development of Communist China*, (Berkeley, University of California Press, 1959) Yang, reference cited in footnote 6, Chao, *op. cit.*, and E. S. Kirby, "The Enigma of the Communes," in E. S. Kirby, *Contemporary China*, Vol. 3, 1958-1959, pp. 152-162.

autonomous village system, in which the historic trends had made for well-developed techniques of avoiding centralized control. The progressive establishment of cooperative farms, fully collectivized farms, state farms, Communes, and similar economic organizations for handicrafts, transportation, and marketing, have reduced the numbers of units to be tapped from well over 100,000,000 to fewer than 100,000, of which some 24,000 were agricultural Communes. Though operating inefficiencies, apathy, passive resistance, even "capitalistic deviation" are present, the increased economic efficiency of capital accumulation and labor utilization has more than offset the deficiencies. This judgment is a net judgment of the total result and is not in contradiction to the judgment that agricultural production, as such and alone, has not tremendously increased.

Whatever may happen to the physical form, number, and size of the residence settlements of China, the economic functioning of the traditional village has been destroyed, but the group operation has been retained. In place of the village has come a changing assortment of centralized groupings whose economic functioning can be directed and controlled from above, and whose output potential can be tapped for utilization in any direction decided upon. The need to maintain the sense of group activity, cooperation, local initiative, and at least tolerance, if not good will, means that there will be waxing and waning in the degree of centralization, there will be tactical variation in the project patterns to which energy is applied, and there will be further change in organizational structure. If this whole effort succeeds at all it will be a tremendous step in the reorganization of a traditional economy. An individualistic collection of small autonomous villages will have been more highly centralized than in any other country. It may be some decades before mature organizational structure appears to stabilize its patterns, and there may be even large scale reversions to a less centralized pattern of operation.

3. *The City.* The Chinese city began undergoing cultural change in the late eighteenth century, when Europeans, with their own culture complexes, began to accumulate in numbers in a few coastal Chinese cities. The nineteenth century saw the process increase, and cultural change in the cities of China has been marked in the twentieth century. This, superficially, took the form of breaching or removing walls, widening and paving streets, installing light, power, water, sewage, and transportation systems, adopting European architectural traits, and developing modern warehouse and factory installations. Culturally, the city often became a curious composite of both traditional Orient and modern Occident. Functionally the city has changed hardly at all, for it still is the center of control and culture for Chinese society. In that national control was, and is, centered in a political capital, the capital has always been unique. The Chinese Communists chose to return to Peking (both the site and the name) partly because of its very aura of historic power and glory, the best known of all Chinese political capitals.

The Chinese Communist programs of economic development in the first years centered on those existing cities that were already developed as to industry, transport, and labor skills, but more recently they have begun to create new cities out of old villages, towns, or mineral resource

sites. These new centers are economically functional as regional foci, and as industry develops regional-divisional aspects some of the new cities will become very important. As cultural centers they become expressions of "politics" and the distributaries of the "mass line." To the degree that the industrial orientation grows and assumes dominance in future Chinese society, the city will share that dominance. There is little evidence, so far, that the total role of the city is being changed from that of earlier time, so the city may remain the residence of the social, economic, and political elite and such other people as can somehow gain entry. Cities are growing both larger in population and in area. Peking by 1958 had been expanded to 6,552 square miles, including most of the mine sites and industrial plants around it. But the tendency to drive the peasantry back to the rural country side and to demote urban functionaries to periods of service in rural areas preserves the classical distinctions between rural and urban residence.

4. *Social Organization*.¹⁸ Communist restructuring of the social organization of China is still in process, and a final or stable pattern has yet to emerge. However, in broad terms the goal can be stated as the complete recasting of social structure upon economic-political lines compatible with the political goals of the Communist state. This has so far promoted tremendous social mobility, in respect to status and position within the framework, by liquidating or reducing to a low level the former upper classes and by elevating cooperative individuals, chiefly the former lower classes, to a higher status. In a sense the result has been similar to that of earlier traditional periods of turbulence associated with dynastic shifts, in which the most objectionable members of the upper classes were stripped of their positions, wealth, power, and status, the debt pattern was rearranged, and some new additions were made to the upper classes. Many of the same historic techniques have been used which have won the support of the lower sectors of society, who see in the procedure an opportunity to wipe the old slate clean and to advance to a higher level and status.

In the early years of the Communist regime official pronouncement arbitrarily divided the population into five classes: landlords and big merchants, national bourgeoisie (traders, merchants, factory owners, town and city dwellers with investments in productive economic patterns), petty bourgeoisie (the rich and middle peasant landowners, master craftsmen, business and industrial clerical personnel, professional classes, lower government functionaries, and the like), semiproletariat (tenants, poor peasants, handicraft workers, shop assistants, peddlers), and proletariat (the landless rural peasantry, town and urban manual labor, the rank and file lower segment of the population low in wealth, skill, and status, but high in "political consciousness" and therefore willing to support any political program that would improve their status).¹⁹ This classification of social structure is an obvious but very purposeful and arbitrary arrangement of groups of people for economic and political ends. It cut through the traditional social structure of scholar, farmer, artisan, and merchant in terms of wealth, power, and status, placing in the landlord-big merchant and na-

¹⁸ Hu, *op. cit.*, Wu, *op. cit.*, Hughes and Luard, *op. cit.*

¹⁹ See Hu, *op. cit.*, pp. 148-152, for specific identification of groups and Wu, *op. cit.*, pages 126-140 for the interplaying of classified categories.

tional bourgeoisie groups all those persons whose vested interests would make them object to the Communist Revolution. By 1960 the first two classes (landlord-merchant and national bourgeoisie) had been liquidated, eliminated, reoriented, brainwashed, driven out of China, or driven underground, and control of China lay in the hands of a new segment of the population, who have been busy erecting the elements of a new social structure around themselves. Social structuring under the new regime is taking political and economic directions, as could be expected, and upward mobility of formerly low-placed persons and biological family units is taking place.

An interesting speculation, as an aside about the workings of the program, concerns the question of what has happened, and what will happen, to many of the former great and leading families. Liquidation of many of these families took place, but was it so efficient as to wipe out all able members? The switching of loyalty, "getting on the bandwagon," and "joining the opposition" have been frequent, and it would be strange indeed if numerous former high-ranking members of society had not been able to maintain themselves and their own biological family units under the new regime. However, the constant re-examination of loyalty to the Communist Party continues to turn out "traitors," "rightists," "imperialists," "deviationists," and others, some of whom may well be status opportunists who too quickly abused their new status, but others of whom may be members of old families.

At the very top of the new structural hierarchy are the veteran leaders of the Chinese Communist Party, among whom there have been singularly few liquidations.²⁰ Grouped below the top echelon are several ranks of party members, their status dependent upon their years of service, outright ability, and patterns of unswerving loyalty. The Party membership of some thirteen million constitutes the elite social group, a group considerably larger than the elite of the classical China. Ranked below them are the new industrial workers, members of the trade unions, and the more skilled of the handicraftsmen. Fringe benefits and status symbolization are bringing position in the social hierarchy to this group which, in 1960, numbered in the vicinity of twelve to fifteen millions. The "cadre" membership, the group of activists who carry out party policy at all levels, slowly is achieving a third-ranking status level. Some of these are new or low-placed party members, but others are village opportunists who are willing to carry out party chores in return for status and fringe benefits of a simple type.

The professional, scholarly, and scientific groups in Communist China currently are not faring well, and often find themselves somewhat shoved aside in the new structuring of social patterns. During 1959-1960 the strong emphasis upon "people's research," as opposed to scientific research by a scholarly class, indicated that the scholarly and professional classes were not making a significant place for themselves. Many such indivi-

²⁰ See Hu, *op. cit.*, pp. 150-156, for specific comment. Since the whole matter of class emergence and reconstruction of social organization is so volatile and current, there is little firm data on the subject, and these paragraphs obviously are tentatively written.

duals have given but lip service to the Party as such, and it is clear that social status is to be earned more by Party loyalty, following the "Mass Line," and practical accomplishment than by purely scholarly achievement.

The army also stands in a position somewhat aside from the main structural patterns of social organization. In classical tradition good men seldom belonged to the army, except in times of crisis, and to a considerable extent this remains true in Communist China. The special position of the early revolutionary army and the political status of its leaders gives the army stronger position and higher status than in earlier China, but it would appear that status is derived from political loyalty rather than military existence, as such.

In general "the people" remain the "little people" as in earlier time, and leadership is confined to the aristocratic elite, though of a new type. The frequent use of linguistic terms for peasantry by highly placed party members implies a distinction between the new elite and the commoner. The destruction of the old class patterns primarily had economic and political objectives. The development of new class patterns is not yet mature, and Communist Party membership does not carry those privately owned, hereditary and vested interest elements characteristic of the scholar-landlord Confucianist class. However, the replacement of Confucian dogma by Marxian and Mao dogma finds the same cultural processes at work, and slowly the Communist Party membership is acquiring the status and prerequisites of the former time. It is notable that the early pictures of Mao Tse-tung, Chou En-lai, Chu Teh, and others of the ranking leaders showed them wearing wadded cotton clothing of a common sort, living in poor housing like that of the "people," and eating in poor surroundings. Recent pictures of ranking leaders show entirely different conditions. The too rapid acquisition of prerequisites by middle-ranked leaders lays them open to attack by opportunistic lower-ranked persons seeking their own patterns of increasing status.

Though traditional Chinese social organization was not extremely highly developed in class terms, there was clear distinction between the "little people" and the "aristocrats"; power and wealth lay in the hands of the latter group, who recruited enough new members to keep their ranks full. The accumulation of a landless tenancy was economic rather than social, but is provided the sheer weight of pressure which the Communists could utilize to destroy the control of the former aristocratic sector. The modern development of international trade and industry in the coastal cities of China gave rise to a banking, business, industrial, trading group which economically was closely related to the old aristocratic sector, and often inter-related to them by family ties. The destruction of these two groups wiped out the economic control of Chinese society, and socially left the Chinese population in a relatively cohesive and socially unstratified state which made relatively easy the introduction of the new social patterns based upon the Party, industrial union labor, and affiliated organizational elements. Thus the Communist program has remained fairly close to the traditional pattern of loose social organization without sharp stratification, containing sufficient fluidity that dissident persons can be dropped down-scale and solidly loyal ones can be moved up-scale.

5. *Chinese Egocentricity.*²¹ It is clear that Chinese ego is being more strongly expressed in recent years and that the psychological and cultural attitude of the Chinese has not changed at all. The feeling that "the East Wind is prevailing over the West Wind," that all imperialists are paper tigers (fierce-looking but empty inside), and that Maoism is constructively reorienting Marxism philosophy, runs throughout the policy line of the Chinese Communist Party, and is the attitude reflected by the people of China. The active and aggressive position taken by the Chinese with regard to the Asian-African spread of Communism is ample indication that merely a new version of "we, the civilized," is on the rise. The "peaceful acceptance" of Chinese Communist culture cannot be expected among the barbarians today because of the "evil machination of the imperialists," and the sense of manifest destiny and political imperialism is returning to the Chinese in an emphatic way. The tactical patterns of operation have been sharpened by Communist strategy, national minorities within China are being made into Chinese at an increasing rate, and the extension of the attitude abroad is precisely the attitude that brought earlier Chinese emperors tribute from surrounding peoples in earlier time. Here Chinese reference does turn to history and reminds Chinese that, though former emperors were "feudalists and imperialists," the former high status of China was well deserved and proper.

6. *Agrarian Orientation.* There is no question but that Chinese Communist policy has tried to destroy the full completeness of the earlier agrarian orientation of the people of China. Here the effort has been not to destroy totally such an orientation but to reshape it in such a way that a major industrial orientation may be erected within Chinese economy. An agrarian orientation that viewed too much mining of minerals or too many railroads and factories as disturbing to the harmonics of the landscape, an orientation that declined to utilize natural resources other than soil, an orientation that declined to use machines when human labor could accomplish the task, had completely stifled the growth of Chinese economy. The Free World has sought the same ends in preaching industrialization to the underdeveloped peoples of the earth.

There is indication that, in the effort to break the agrarian orientation of the Chinese populace, the program went too far, put too little into agrarian investment, and neglected the agricultural sector of the economy in favor of the industrial sector. The 1960 corrections of agricultural production figures brought home the realization that the agrarian orientation could not be neglected.²² However, the steady drive to improve agriculture, the industrial output designed for agriculture, the driving of populations back to the farms, and the emphasis given to "people's research" on agricultural problems demonstrates clearly that total destruction of an agricultural orientation was at no point a primary aim. The utilization of

²¹ There is little literature dealing with the specific issue. The point is implicit in much political maneuvering of recent years, reflected in newspaper and magazine reporting. It also is implicit throughout such a study as H. A. Steiner, "Communist China in the World Community," *International Conciliation*, No. 533, May, 1961, pp. 389-454.

²² W. K., "Communist China's Agricultural Calamities," *The China Quarterly*, No. 6, April-June, 1961, pp. 64-75.

all known historic techniques in matters of agricultural endeavor has been notable, and the attempt to improve agriculture is very real.²³

RECAPITULATION

If the above interpretive analysis has merit, the following points stand out in regard to the six suggested basic culture complexes of Chinese society. Communist strategy has been to destroy the old patterns that kept China stably organized as:

1. A collection of large and somewhat intra-dependent families, a few of whom held the reins of control for Chinese society;
2. A collection of almost autonomous village communities, in the economic sense, with decentralized but authoritarian national controls;
3. A loosely structured society in which an aristocratic element perpetuated its controls by taking in sufficient recruits to maintain power;
4. A society kept so oriented to agriculture life that an industrial revolution could hardly take place.

The strategy has been to:

1. To bring to dominance the always present biologic family unit but to strip it of its power resources;
2. To centralize authoritarian controls of persons and groups in such a way as to secure total control but to foster the traditional urge to group activity among the mass of the population;
3. To retain the city as the regional center of power in a more direct line in the chain of command from the national capital;
4. To retain the loose social structuring of the past but to replace the elements of societal control by a new group of persons conceiving of control in new terms;
5. To restore to vitality the egocentricity of the populace in order to enhance internal development as well as the position of China in world society;
6. To retain the agrarian orientation and its traditional practices to the degree necessary to feed the total populace while reforming it along modern productive lines, but with land control totally removed from the hands of families or persons;

²³ C. Chung, "Agricultural Science in New China," *Peking Review*, Vol. 3, No. 47, Nov. 22, 1960, pp. 21-24, spells out a program labelled The Eight Point Charter. These eight points are: deep plowing and soil working, water conservancy, seed selection, closer planting, plant protection (insect and pest control), field management, and tool reform. In addition to listing the new charter, Chung says on page 22: "The considerable achievements gained in agricultural research have demonstrated the importance of the following basic experience. First and foremost is the placing of politics in command, the following of the mass line and the vigorous development of mass movements . . . An excellent feature of the way the mass line has been applied in agricultural research is the close cooperation developed between cadres, scientific and technical personnel, and the masses . . . Secondly this basic experience tells us that research must serve agricultural production and that the theoretical level of research must be raised by summing up mass experience in getting high yields. Thirdly, the policy of 'walking on two legs' has proved to be an important guarantee for the rapid growth of agricultural science . . . a major application of this policy is the integration of specialized research with the scientific activities of the masses. Fourthly, this basic experience tells us that greater numbers of research bases must be set up and varied methods employed simultaneously to attack urgent or complex problems." 'Walking on two legs' is a current slogan referring to the combining of modern science and indigenous-traditional practices.

7. To graft into the basic set of complexes a new industrial culture complex which would produce an industrial revolution;

This latter culture-complex has not been discussed so far, and it needs some descriptive elaboration, for it represents, in some respects, a major re-shaping of traditional Chinese culture.

7. *Industrial Orientation*.²⁴ Though handicraft manufacturing is as old as Chinese culture itself, cultural policy has been to maintain it as handicraft manufacturing, pruning back those developmental features by which it could have evolved into an industrial manufacturing culture complex which could threaten the agrarian orientation of Chinese society. Changing attitudes in these matters were taking place in China between 1890 and 1950, but at such a slow rate of movement and so hampered by traditional restrictions that they could hardly be termed revolutionary.²⁵ Under Chinese Communist control the industrial orientation has evolved a multi-pronged program, set in motion and stimulated by governmental control over the whole resources of Chinese society. Its primary programmatic phases have been:

1. Ultimate confiscation of all foreign-owned industrial properties, concessions, and activities;
2. Initiation of a totally new attitude toward natural resources, their survey, location, and exploitation involving a new concept of the harmonics of the landscape;
3. Development of a totally new orientation toward mechanics, mechanical inventiveness, the use of tools and machines, and their role in economy;
4. Development of a new orientation toward physical labor and labor with machines among all levels of society, in which physical labor is not looked down upon as it was in traditional China;
5. Development of a new educational framework concentrating on technical, practical, trade, and mechanical schools which can turn out persons willing to do skilled and mechanical labor; and
6. The formal initiation of all forms of industrial activity, including transportation development, on a geographically regionalized basis, involving the investment of most of the nations economic resources in the program.

Industrialization programs began with an accent on urbanized heavy industry fairly well divorced from rural, economic, and cultural realities. Bottlenecks quickly developed, such as the disinclination to engage in physical labor, producing such interesting phenomena as widely distributed popular educational propaganda photos of Mao Tse-tung and Chou En-lai working on roads, in factories, and on new buildings. Such bottlenecks led to programmatic patterns four and five above. The sheer need for greater volumes of natural resources led to pattern two, in which low-grade training in geology and minerology has set thousands of people to combing the hills of greater China for mineral deposits. This was something that never could have taken place in Confucian, agrarian China. The curious pattern of encouraging back-yard blast furnaces for the production of pig iron, and the following spree of building "local railroads" during 1959-60 may be eco-

²⁴ For general data see Wu, *op. cit.*, Li, *op. cit.*, Hughes and Luard, *op. cit.*, T. Shabad, *China's Changing map, A Political and Economic Geography of the Chinese People's Republic*, (New York, Praeger, 1956).

²⁵ A. Feuerwerker, *China's Early Industrialization*, (Cambridge, Harvard University Press, 1958), particularly the first two chapters.

conomic idiocy in the strict production sense, but they derived from production and distribution bottlenecks and they also are related to phases two and three of the program. Such beginning and amateurish efforts as back-yard blast furnaces and local railroads may be scoffed at, as production engineering, but they must be viewed also as matters of culture-process development—the initiation of cultural attitudes and willingness toward industrialization among a people heretofore committed to an agrarian society. That millions of people are put to work at hand labor at vast programs, which cannot yet be tackled with big machines, is wasteful, but until that population is willing and able to make and use the machines, Communist policy has ordained that they are best kept busy, exhausted, and quiet.

The new culture complex, industrial orientation, is still young and far from maturity in Chinese society. There is considerable grumbling among the rural populace about deprivation because of the new monster, and there undoubtedly is lingering preference for the quiet rural, agrarian orientation which will die slowly. The industrial orientation will continue to grow, however, for its programmatic features are now sufficiently comprehensive as to promote the whole of an industrial revolution. There are a few signs, even, that a sector of the population is beginning to appreciate the possibilities, though their actual participation in the results still lies chiefly in the future. So long as the Chinese Communist Party remains in power the industrial orientation will grow, for the simple reason that the Chinese Communist Party is more fully committed to industrialization than is the Free World committed to the improvement of underdeveloped lands. It seems almost certain that if the Communist Party should lose control of China in the near future, a happening for which there is no realistic expectation whatever, the industrial orientation of Chinese society would continue to mature into full-fledged industrial revolution under any pattern of control. It would appear that a totally new culture complex has been grafted into Chinese society, however brutally this has been accomplished.

CONCLUSION

Whether those of us in the Free World like it or not, it appears that the Chinese Communist program in China has permanently altered the basic culture of Chinese society in wholesale fashion. Though Chinese society has been a steadily changing society during the 4,000 years of its continuous existence there have been only a very few cases of wholesale change which compare with what is in process today in China. It might be possible to argue that the coming of the Chou into China, about 1100 B.C., initiated such a period of change, though we know too little of the details to be certain about the amount and nature of such change. There is fairly ample evidence that the Ch'in, in the third century B.C., set in motion a wholesale pattern of change that matured in the succeeding two centuries. The cultural experience of the last four centuries prepared the ground for another pattern of wholesale change, and the last century has been a period of cultural, as well as economic and political, turbulence which brought to crisis state the issue of change. The Chinese have outgrown their landscape and their basic culture complexes. Unfortunately for the Chinese themselves, and for much of the rest of the world, the Communist seized the initiative and the controls at a time when such wholesale change could

be made. The Chinese Communist Party has retained certain basic cultural tendencies, modes, and complexes traditionally Chinese, but have destroyed the former functions of many other culture complexes in order to enlarge the total culture of China and reorient it in such a way as to more fully utilize the resources of the geographical territory that has been the traditional home of the Chinese. Communist control of China appears to be firm, but cultural change will continue at a rapid rate, remaining essentially Chinese in nature for all of the alien inspiration it has received. In this last characteristic the present era resembles the two other eras of profound cultural change in China.

AGRICULTURAL REGION AND STATISTICAL AREA: A DILEMMA IN CALIFORNIA GEOGRAPHY

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A problem that has always plagued economic geographers is the lack of conformity between the geographic region and the area for which statistics are reported. It is particularly critical in agricultural geography where the production surface covers extensive areas, unlike industry, and is therefore much more likely to be disturbed by the arbitrary boundaries of reporting areas. The disconformity becomes notably acute in areas such as California, where regional comparisons are vital for an adequate understanding of the agricultural life of the state. Great areal variations occur in the crop complexes, operational systems, and general intensity of California agriculture. Furthermore, important regional changes in these farming elements are also taking place.

Yet the usual "regional" boundaries used by statistical agencies are those of the county, a unit which creates special difficulties for geographic study in California and the rest of the West. County lines do particular violence to areas where there are great ranges of agricultural intensity by combining numerous gradations and also cutting across them. The minor civil division, a tool which permits a closer approach to geographic reality, also has its disadvantages. Although it is much smaller than the county, its boundaries also often lack discrimination because of their artificial nature. The high cost of procuring minor civil division statistics from the federal government is another hindrance. Furthermore, not all agricultural statistics are available on a minor civil division basis, some of the most critical deficiencies being in value of production.

PRINCIPAL BOUNDARY DISCONFORMITIES

The various areas of major disconformities between agricultural region and statistical area become quickly apparent in an examination of the "State Economic Areas" of the U.S. Bureau of the Census (Fig 1-A) and the "Crop Reporting Districts" of the California Crop and Livestock Reporting Service, (Fig. 1-B). These two are the most important regional systems used for statistical purposes in California agriculture. They furnish a framework for reports which appear regularly and which deal with both acreage and value.

Central Valley Margins. By using county boundaries, both regional systems exclude important agricultural sections along the eastern margin of the Sacramento Valley, particularly in Nevada and Placer counties. Although the hilly nature of some of this terrain would make it more similar to the Sierra Nevada than the Sacramento Valley, the agriculture certainly has much more in common with the Central Valley than the small Alpine meadows of the Sierra or the valleys of the northeastern interior. Another

discrepancy of this order but on a smaller scale is the inclusion of the northern tip of the Sacramento Valley (Redding area) with the climatically different northeastern interior valleys. A more serious situation, however, is the inclusion by the Census Bureau of a sizable chunk of the Sacramento Valley (Solano County) in the Central Coast region.

Except for small marginal strips in the extreme northeastern and northwestern corners, the San Joaquin Valley is relatively free of divergencies between agricultural region and reporting area. One saving thing to the correlation problem in California and the West is the tendency of county lines to follow mountain divides or other topographic features that are hos-

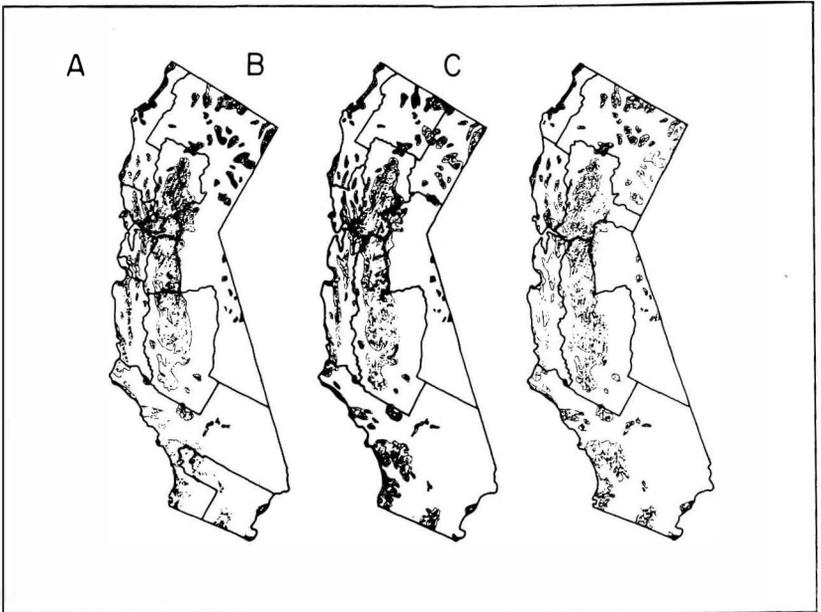


Fig. 1

tile to agricultural development. But this, however, is of little help if the topographic region includes highly diverse agricultural regionalisms, or if topographic boundaries are used as statistical-area boundaries in some places and ignored in others. The cases of the Central Coast and Southern California are, respectively, good examples of these discordancies.

Boundaries of the Central Coast Region. Both northern and southern boundaries of the Central Coast region, as used by the "state economic area" and "crop reporting district" systems, are evidences of boundary disharmonies. In the north, in Mendocino County, several of the interior valleys are included with the dissimilar agriculture of the north coast. The discrepancy is even greater for the state economic areas, since Lake County is also included in the North Coast area. However, it should not be forgotten that each regional system has a primary purpose, and one that does not necessarily include the characterizing of the agricultural region. The exclusion of Lake County from the Central Coast region and the inclusion

of part of the Sacramento Valley (Solano County) by the Census Bureau therefore becomes more logical, since the Bureau is also interested in Metropolitan Areas: Lake County obviously has little to do with the metropolitan complex of the Bay Area, while Solano County includes Vallejo, an important segment of the Bay Area urban complex.

In the south, both "state economic area" and "crop reporting district" systems allow such areas as the Santa Maria Valley to be incorporated in the more intensive fruit and nut region of southern coastal California. On the other hand, to include the valley in the Central Coast region would merely substitute one problem for another, since Santa Barbara County includes both the Santa Maria Valley and the Santa Barbara littoral.

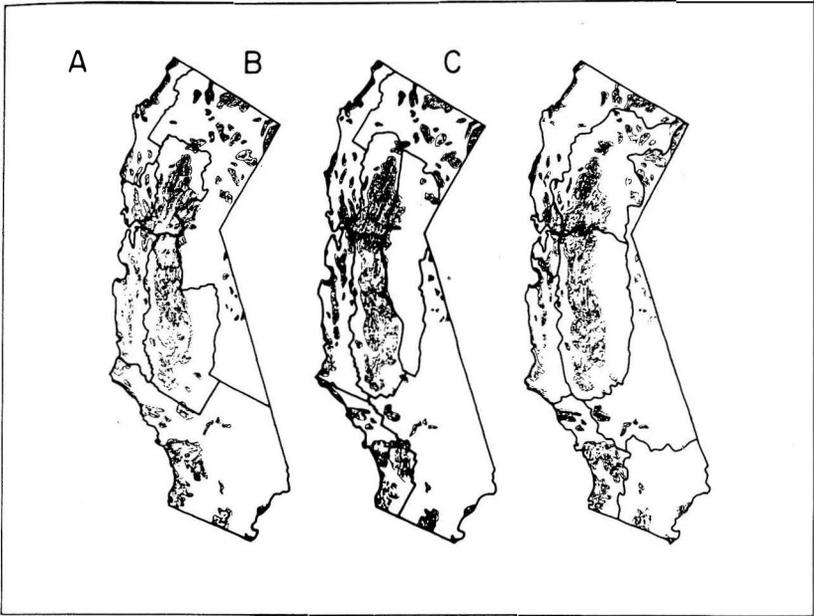


Fig. 2

Coastal and Interior Southern California. By far the biggest vexation to the agricultural geographer interested in California is the failure of regularly reporting statistical agencies to separate coastal and interior Southern California. One need not go into detail here on the many contrasts, not just agricultural, between such places as the Owens Valley of the "High Desert," the Imperial Valley of the "Low Desert," and the coastal region (South Coast). Only two of the eight counties that form the southern end of the state have boundaries which enable the researcher to make a clear division between coastal and interior agricultural regions: Ventura and Imperial. The Census Bureau uses the Imperial County line for part of the boundary of one of its state economic areas. This particular economic area (Number "8") also encompasses Riverside County, thereby including all principal agricultural regions of the Low Desert. Unfortunate-

ly, a statistical picture of Low Desert agriculture is still impossible since Riverside County includes significant croplands on both sides of the southern coastal ranges.

ATTEMPTS AT SOLUTION

Several governmental agencies and individuals have devised regional systems which correct some of these discrepancies between agricultural regions and statistical areas. The system set up by the Bureau of Agricultural Economics in the U.S. Department of Agriculture is somewhat unique in that it is designed expressly for representation of a particular kind of agricultural region on a geographic basis, *i. e.* the "Generalized Types of Farming." However, the regional system is not a vehicle for statistical reporting and is based on material that is already available to the Agricultural Census or unpublished Census data. Nevertheless, the value of the system to the researcher in agricultural geography puts it in a category of usefulness second only to the regionalization schemes of the Census Bureau and the state's Crop and Livestock Reporting Service.

Fig. 1-C shows the regional framework employed by the Bureau of Agricultural Economics. County boundaries are again used,¹ but their unit arrangements make for some improvements. By including Mendocino County in the northern part of the Central Coast region, all of the interior valleys are finally—and properly—excluded from the more oceanic type of agriculture in the North Coast valleys. This same maneuver, however, assigns a small coastal strip with agriculture similar to that of the North Coast to the Central Coast. The Bureau makes another improvement over the regional frameworks of the state economic areas and the crop reporting districts by including the cropland of Nevada and Placer counties within the Sacramento Valley region. Solano County, excluded from the Sacramento Valley by the system of state economic areas, is also included in the Valley by the Bureau.

Three other regional systems also try to use boundaries that are more conformable to the agricultural region. They are the "Farming Regions" of Shultis,² the "Physiographic Regions" of Crawford and Hurd,³ and the "Major Hydrographic Areas" of the California State Water Resources Board.⁴ Unlike the system of "types of farming areas," these three are designed for statistical presentations; but also unlike the systems of "state economic areas" and "crop reporting districts," they involve no periodical statistical surveys.

¹ David Weeks offers an excellent comparison of two maps showing "generalized types of farming" for California and the Southwest, one showing the county boundary basis used for gathering statistics and the other geographic regions into which the data is translated. "Rural Land-Use Types and Regions," *California and the Southwest*, ed. Clifford M. Zierer (New York: John Wiley & Sons, Inc., 1956), Chapter 12, pp. 124-25.

² A. Shultis, *Agriculture in California*, Calif. Agric. Exper. Stat. Circular 474, 1959, p. 19.

³ L. A. Crawford and E. B. Hurd, *Types of Farming in California Analyzed by Enterprises*, Calif. Agric. Exper. Stat. Bulletin 654, 1941, p. 37.

⁴ California, State Water Resources Board, *Water Utilization and Requirements of California*, Vol. II, 1955, Plate 8.

Shultis' "Farming Regions" improve upon the regional structure of the state economic areas by eliminating the Solano County salient in the Sacramento Valley and including more of the northern interior valleys in the Central Coast region (Fig. 2-A). The Shultis system is almost identical to that of the crop reporting districts; it therefore also has the same disadvantages in comparison with the "type of farming" system outlined by the Bureau of Agricultural Economics.

The regional organization by Crawford and Hurd makes a notable advance by separating coastal and interior Southern California; the Santa Maria Valley is assigned to the Central Coast region (Fig. 2-B). On the other hand, several boundaries are drawn in such a way as to raise controversy, at least from the standpoint of land use uniformity. The creation of a Sierra Nevada region may be good for analysis of the livestock industry, but is poor from the crop standpoint in that it combines the agriculture of the eastern Central Valley margins with that of the valleys of the steppe interior. The inclusion of such areas as around Mono Lake with the agricultural areas of the Antelope Valley, and certainly with the Low Desert oases of the Imperial, Coachella, and Palo Verde valleys, is also questionable. Another inconsistency is the extension of the North Coast region southward to the Bay Area, thereby including the intensive fruit, truck, and mixed farming economy of the the North Bay counties with the more extensive dairying economy of the North Coast.

The closest approach to an agreement between the reporting area and agricultural region is that involving watersheds. The most thorough application of this regional system was made by the California State Water Resources Board for the 1946-53 period, when it organized land use data on the basis of seven major hydrographic areas and 129 hydrographic "units" (only the hydrographic areas are noted in Fig. 2-C). That the information was gathered during a period of several years rather than for just one season may perhaps be designated as one weakness. Another weakness is that no land use information other than acreage was collected.

BENEFITS OF AN IMPROVED REGIONALIZATION

Geographers will obviously have to content themselves with approximations of geographic areas for statistical purposes for a long time to come. In a country as large as the United States and where the Census Bureau budget is but one of many, costs will always remain a formidable barrier to any extensive expansion in research and publication programs. The rewards of an improved regionalization are great, however, and they will continue to stimulate attempts toward an improved correlation.⁵

⁵ For one such attempt at a more improved regionalization of California and its statistical revelations, see H. F. Gregor, "Agricultural Intensity and Its Regionalization," *Yearbook of the Association of Pacific Coast Geographers*, Vol. 22, 1960, pp. 7-27.

THE INFLUENCE OF ECONOMIC CHANGE ON THE POPULATION OF SOUTHEASTERN ALASKA

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Southeastern Alaska is a narrow strip of mainland together with a chain of islands that lie along the Pacific Ocean just north of the state of Washington. Everywhere the region is mountainous and the only level land for towns is on the coastal plains (Fig. 1). The many channels, straits, canals, and passages that separate the islands from the mainland and from one another also drew men to the edge of the sea because of the presence of fish and fur-bearing sea animals, and the convenience of water transportation. Thus, in all periods of the region's history the people have clustered along the mainland coasts or along the coasts of the many islands.

Furthermore, the people of Southeastern Alaska have tended to cluster in urban places. There are thirty-eight communities and they account for more than eighty-seven per cent of the entire population of the region. Southeastern Alaska has virtually no rural population. The people, Indian and white alike, live exclusively in or around small towns and make their living in the industries peculiar to each. Although the United States Bureau of the Census considers as urban only communities of 2,500 or more, the classification is not applicable to Southeastern Alaska where even places much smaller than 2,500 must to be considered as urban because of their economies. Since Southeastern Alaska has a very sparse population, economic character rather than number of people determines whether a town is to be classified as urban or rural. Compared to the United States, all Southeastern Alaskan towns are very small. They are nevertheless almost entirely urban.

The prominence of particular towns has varied as the economies of the region have varied. There have been three outstanding periods that have affected the size, number, and location of communities. They were fur trapping, gold mining, and fish catching. Each period, in its turn, has its peculiar effect on the communities. The success of places depended on their having (1) a hinterland of fur-bearing animals, (2) being near valuable minerals or on a convenient route to them, or (3) being near good fishing grounds. Often the size and distribution of population is important if labor is a major criterion for the location of a subsidiary industry in a particular place. Such was the case for the white man's exploitation of furs in Southeastern Alaska. The white fur traders depended upon the Indian population for a reliable supply of furs and the established Indian population of Southeastern Alaska gave the traders that reliable supply. However, the culture of the Indians differed so greatly from that of white men that the effects of a commercial fur economy on each were not the same. The contrast was no less different in the ensuing economies of gold mining and fishing. Truly, significant population changes have occurred as a result of the different ways various economies have affected each race.

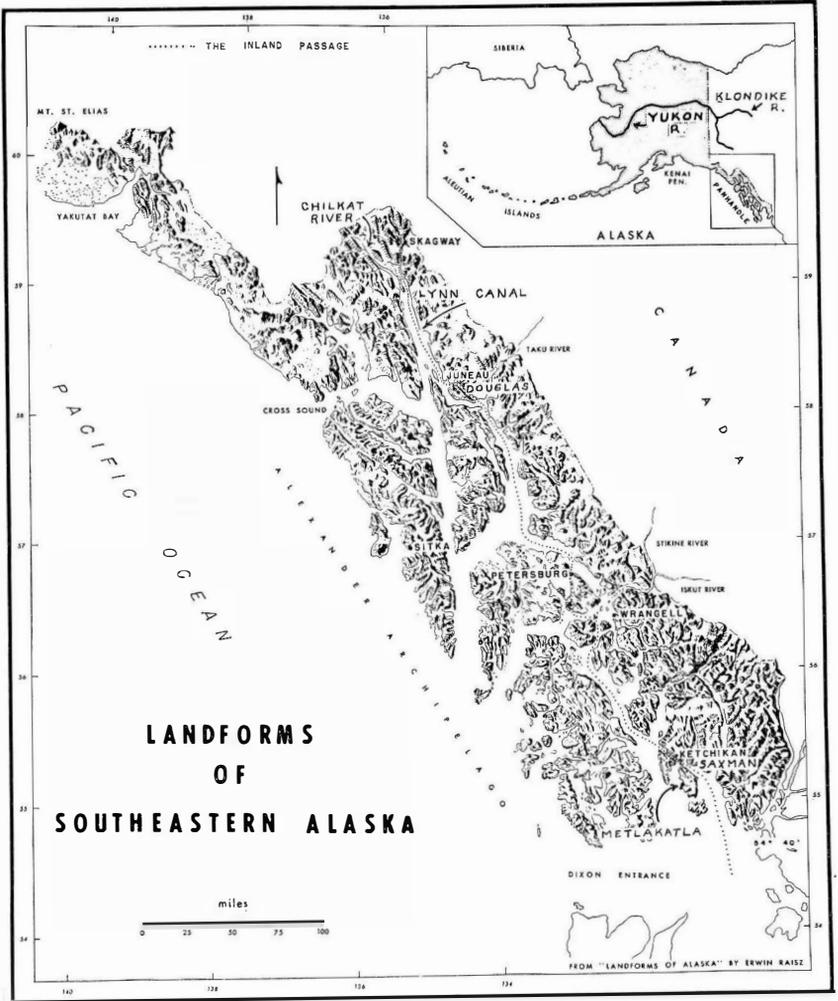


Figure 1

In the early history of contact between the two races, the Indian population greatly affected the white population; in more recent history, the relation has been reversed. Although the Indians were little changed by the coming of white men, the presence of the Indians in certain numbers and at particular places governed the initial distribution of white men. In 1800 the first trading posts of the white traders were necessarily located where Indians were most numerous. The large Indian villages, located along the coasts and housing a labor force for the gathering of furs, were especially ideal. The Indians knew the woods and waters of their region, and the haunts of fur-bearing sea animals, especially the sea-otter. Since the sea-otter was the most used fur of the Indians for clothing and was the most frequently caught, it became the major article of trade among the Indians and with white men.¹ So long as white men were primarily interested in furs, their distribution was determined by the location of the Indian population.

It is a decided advantage for an area to be on an established world trade route. Conversely, it is disadvantageous to be far from such a route and the detriment to trade increases with the increase of the distance from the route. To offset the added cost of transportation for outlying communities, a product must have high value per unit of weight. Prior to 1880, Southeastern Alaska was unable to produce such an item. The trade in furs, though important to an extremely small number of persons and places, was no match for the well-established fur trade of Southern Canada and Western United States. Fishing was still only for subsistence. The product needed by Southeastern Alaska to lift her from the level of an undeveloped outpost first came to her at Treadwell Mines near the present site of Juneau, where in 1880, gold was discovered.²

In 1880 Juneau was founded at the mouth of Gold Creek, just north of the mouth of the Taku River. By 1890 the population of the town had risen from almost nothing to 1,253, and Juneau became the largest town in Southeastern Alaska, indeed in all Alaska.³ Except for a short period just before 1900 when she was forced to relinquish the title to Skagway, Juneau has maintained the largest population of any town of Southeastern Alaska. However, the hundreds of people who came to Juneau between 1880 and 1890 found that the best claims had already been taken and that the quality of the ore was not as high as was at first thought. Thus, soon after 1890, gold mining in Juneau slowly began to decline. The reduction was so slight, however, that the reaction of the population to it was delayed. Though less gold was being mined between 1890 and 1900, the population of Juneau increased from 1,253 to 1,864. Many people still had dreams of quick wealth and the Inland Passage made ship travel from the Pacific Coast of the United States to Juneau comparatively easy and inexpensive.

¹ Miner Bruce, *Alaska: Its History and Resources, Gold Fields, Routes, and Scenery*. (New York and London: The Knickerbocker Press, 1899, p. 63.

² J. A. Hellenthal, *The Alaskan Melodrama*. (New York: Liveright Publishing Corporation, 1936), p. 165.

³ U. S. Bureau of the Census, *Twelfth Census of the United States: 1900. Population*, Vol. I, p. 406.

DISCOVERY OF GOLD

In 1886, gold was also discovered at the Porcupine mines about one hundred miles to the north of Juneau near the town of Haines and the northern end of Lynn Canal. However, the Porcupine gold era was short lived because the gold was ill-placed, low in quality, and not very abundant. Comparatively few people ventured there. The town had been originally founded at a trading post for the Chilkat and Interior Indians and only the advantageous site of the town at the mouth of the Chilkat River allowed it to prosper during the rush for gold. The Inland Passage, in order to take people to the Porcupine gold mines, followed Lynn Canal from Juneau and now terminated at Haines.

The Juneau and Porcupine rushes were but minor introductions to the real gold era, for the gold mines that were to bring people to Southeastern Alaska by the tens of thousands were yet to be discovered. They were revealed in 1896 and 1897 in the interior of Yukon Territory. The place was near the confluence of the Klondike River and the Yukon.

The best route from Seattle to the gold was through the Inland Passage of Southeastern Alaska to the extreme northern end of Lynn Canal, seventeen miles beyond Haines. Here the Skagway valley penetrated the Coast Range and allowed convenient passage to the headwaters of the Yukon River and thence to the Klondike.

Skagway, which had been in existence only thirteen years before the Klondike discoveries, prospered as the major port of entry to the gold fields. In 1898 the population was estimated as being between 15,000 and 30,000; but in 1900, when the first official census was taken, the population was only 3,117.⁴ Skagway's gold rush era was no different from those of Haines or Juneau in its abrupt ending.

At the turn of the century the great gold rushes of the Klondike, Juneau, and Porcupine mines were completed. Large numbers of people had filled the towns of Skagway and Juneau, and even Haines accumulated quite a few people who had come for gold. If large populations did not last, the rushes at least brought to Southeastern Alaska, as well as to separate communities, their first world notoriety. There were very few communities born of the gold rush era, and they prospered greatly, especially Juneau and Skagway. But nearly all of the other communities of the region, most of which were small Indian villages, remained unchanged.

DEVELOPMENT OF THE INLAND PASSAGE

Perhaps the greatest benefit of the gold era, however, was the development of the Inland Passage. For, in the decades to come, the Passage was to extend prosperity to a great many other towns and villages.

In the regular ship travel that developed among the islands and along the coastal mainland of Southeastern Alaska, certain routes, passages, and channels became more frequently used than others. Their advantages were often the depth of the water, or the width, or even the shortness of the channel. For the most part the Inland Passage was the path of least resistance from the United States to and through Southeastern Alaska.

⁴ Edwin J. Foscutt, "The Development and Decline of Skagway, Alaska," *Economic Geography*, Vol. X (1934), p. 425.

At first the Passage terminated at Juneau, then it reached as far north as Haines, and eventually it ended at Skagway. The Inland Passage was created during the gold rush era, but the greatest use of the Passage was to come on a later period when nearly all communities of Southeastern Alaska on or near it were to prosper.

The year 1900 is significant in the history of the development of Southeastern Alaska. It is from that date that the region shook from itself the unstable fluctuations of the number and distribution of people, caused by the erratic economy of gold rushes, and began to stabilize its economic development through the additions of fishing, lumbering, fur farming, trade and commerce.

Commercial fishing was of intermediate importance to fur and gold in that it helped establish a permanent white population that was not nearly so large as the population which existed during the gold rushes but was considerably larger than the population which had at one time venerated Southeastern Alaska in trading posts. Strategic location for commercial fishing towns was associated with existing Indian settlements. Fishing was basic in the life of the Indian, and his livelihood was more linked with that occupation than with any other. The pattern of Indian population throughout Southeastern Alaska showed an intense concentration along the shores of the mainland and of the islands. For once the desires of white men differed little from those of the Indian, namely, to be near waters that abound with fish. The white men's towns also had to be established at places that were near markets and on convenient routes of transportation. However, they were still largely guided by the best locations of fish and, therefore, closely tied to the pattern of Indian settlements.

Commercial fishing began slowly but was accelerated and became the principal base for the general economy of Southeastern Alaska. The discoveries of gold in the 1880's led to the use of the Inland Passage to supply the gold fields with people and mining material from the south. As a consequence of the added shipping, the commercial fish industry, scarcely started and flexible in its youth, quickly conformed to the Inland Passage. All commercial fishing centers established since the turn of the century have been intentionally located directly on the Inland Passage.

In 1900 the population of Southeastern Alaska tended to cluster along the mainland and on the leeward islands of the Alexander Archipelago. It was greater in the north than in the south as distribution was still determined by the events of the gold era. Though that era was at an end, it showed the importance it had once held by its continuing to be the major determinant of the distribution of population in Southeastern Alaska until nearly 1910. In 1900, Skagway contained more than 3,000 people and Juneau had nearly 2,000. Though both were declining, in 1900 the two communities alone accounted for more than one third of the entire population of Southeastern Alaska.⁵ But as these two communities of the northern part of the region clung to the last vestiges of their most prosperous era, communities to the south were discovering new occupations, and their success is indicated by the increases in their populations.

⁵ U. S. Bureau of the Census, 1900, *loc. cit.*

Of the twelve communities of Southeastern Alaska that have a continuous record of population from 1900, four are oriented toward the ocean and eight toward the Inland Passage. Four of the eight, Skagway, Haines, Juneau, and Douglas, are in the north, and the other four, Wrangell, Ketchikan, Saxman, and Matlakatla, are in the south. The population of the four northern towns declined in the decade from 1900 to 1910 more than twenty per cent. In the same period the total population of the four southern towns increased nearly one hundred per cent. The redistribution of the population was a sign of the changing economy of the area.

Fish were abundant and they could be found nearly everywhere along the coast and among the islands. The criterion for their exploitation was not their specific location or amounts, but the availability of a market for their sale. Where formerly only a few communities profited from the discovery of gold, now many prospered from fish. Those on the Inland Passage prospered the most.

The communities in the southeastern part of Southeastern Alaska were in an ideal position. The nearness of the southern towns to the markets of the United States allowed them to capture the fishing trade better than communities farther north. Also, as a result of their location at the southern end of the Inland Passage, they influenced in some form or other all trade going to or coming from the United States. The nature of the development of the southern end of Southeastern Alaska is exemplified in the rise of Ketchikan to prominence.

The location of Ketchikan at the Alaskan entrance of the Inland Passage and at a focus of a myriad of channels and straits, and islands with many bays and inlets that abound with halibut, and salmon, lured industry and trade. In addition, the city's proximity to the United States was an ever-present advantage in the town's development. In the census of 1960 Ketchikan was almost the largest city of Southeastern Alaska, exceeded only by Juneau. Although Ketchikan's location is commercially superior to that of Juneau's, Juneau gains additional advantage as the political capital of the state of Alaska as a whole.

THE FISHING INDUSTRY

The development of the fishing industry of Southeastern Alaska has been slow. The small population of the region allowed only a few communities to develop as major centers of commercial fishing. With only one exception, every community of the region now has fishing as a major part of its economy. Most of the smaller communities catch fish for subsistence, while others may do a little commercial fishing too. The small communities that engage in commercial fishing in any way are all located in the immediate vicinity of the five major commercial fishing centers. Thus, the urban pattern of Southeastern Alaska, based on commercial fishing, has four kinds of towns: (1) The master centers of Juneau and Ketchikan with populations of more than 6,000 which, through advantage of geographic location, govern the commercial fishing industry, (2) the centers of Sitka, Wrangell and Petersburg, with populations between 1,000 and 6,000, which have limited self-sufficiency in commercial fishing and, though dependent in part on Juneau and Ketchikan for commerce and trade, act as

centers for many small fishing communities in their immediate areas, (3) the minor fishing towns with populations of 500 to 1,000 that have commercial fishing on a small scale and are completely dependent upon the major centers for marketing, and (4) the small fishing villages with populations generally less than five hundred that exist only for subsistence fishing, but on occasion use fish for trade to obtain essential goods. Thus, commercial fishing, the third significant stage in the economic development of Southeastern Alaska, is the single greatest factor in creating the distribution of population that exists today.

SUMMARY

The towns of Southeastern Alaska were born of various eras based on furs, gold, or fish. Some prospered, some did not and died with the economic eras that created them. Sitka, on the Pacific, thrived on furs; Juneau and Skagway, in the north, profited from gold; and Ketchikan, in the south, prospered from commercial fishing. The population trends of those cities and many of the towns and villages associated with them were irregular, but there was purpose for their being. How they were to develop depended upon the advantages they possessed for fur trapping, mining, or fishing. However, the resource and market bases for each of these were constantly changing and thus the economy and occupancy of the towns changed.

A new and different economy that is conducive to the support of reasonably large numbers of people could be developed in Southeastern Alaska, namely an economy based on water power. The topography and climate are nearly the same throughout the region, and thus, the advantages for water power are found in many communities. Skagway is one such community. Other outstanding power sites are near Juneau, Wrangell, and Sitka. The power is there, but whether or not its over-all advantages are great enough for industry to seek it out is not known. A new era, whatever it be, cannot help but be influenced by the present pattern of occupancy of the region, and that pattern will, in its turn, help condition the new trend of population.

LANDSCAPE, WATER, AND OUTDOOR RECREATION IN THE EASTERN SIERRA NEVADA

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The Sierra Nevada has appropriately become one of the major natural attractions in the western United States and assumes great importance in the outdoor recreation industry of California. This is due to some obvious factors—marvelous scenery, vast expanses of primitive mountain land, and large nearby population centers. But within local Sierran regions, less obvious qualities of the natural scene sometimes exercise considerable influence over the popularity and use pattern of an area. Such is the case with the eastern slope of the Sierra Nevada, where a minor physical change along the mountain crest has caused profound differences of landscape and hydrography to occur. These differences have, in turn, caused two contrasting patterns of recreational land use to exist side by side.

Although these physical differences have been briefly noted in geologic and hydrographic reports, and are readily discernible from detailed topographic maps¹, the resultant land use patterns have not heretofore been described in the literature. The data in this report were collected by the author while doing field work in the Owens River drainage area during 1960.

PHYSICAL DIFFERENCES OF THE EASTERN SLOPE

Due to the characteristic profile of the Sierra Nevada, with a long gradual western slope and a short, abrupt eastern escarpment, the crest of the range is very close to the eastern slope and plays an important role in that slope's use as a recreation area. Because of this proximity between the crest and the east slope, a seemingly minor change in the trend of the crest above Owens Valley causes the Eastern Sierra to have two basically different recreational functions.

From Mt. Whitney, the crest assumes a general, near-northerly direction for some forty miles. But at a peak called the Thumb, west of the town of Big Pine, the direction of the crest shifts slightly, veering more to the northwest, in a manner that substantially alters the nature of the Eastern Sierra watershed, (Figure 1).

Southern Section—The section of the eastern slope south of The Thumb consists of the great Sierran escarpment, an impressive granite wall marking the massive block upthrust that occurred along a fault zone at the western margin of Owens Valley. This is a region of great relief, rising nearly 11,000 feet from the valley floor to the crest. Valley glaciers were active here, leading out from the central ice cap that covered the higher elevations of the range, and they scoured numerous cirques in the summit

¹ Army Map Service topographic sheets (1:250,000) and U. S. Geological Survey topographic sheets (1:125,000).

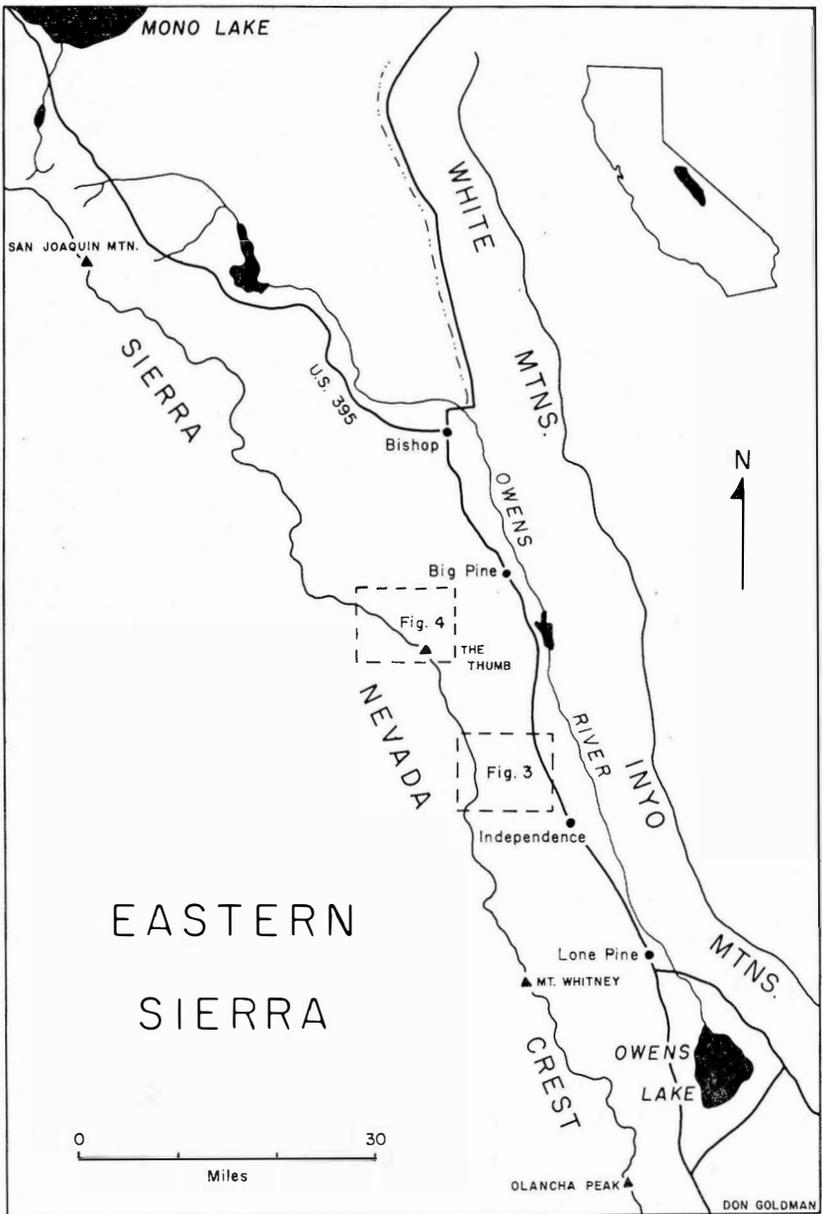


Figure 1

areas.² But due to the short slope and the resultant small catchment basins, relatively little ice collected. Because the escarpment is so steep, these small glaciers advanced only short distances before warmer air at the lower elevations melted them. Thus, while glaciation was reasonably intense in the upper elevations, the ice had little opportunity to modify greatly the lower canyons.

This section of the Sierra is a bare, rugged, windswept slope. There is almost no level land; trees are restricted for the most part to riparian locations in the steep canyons and to small glaciated platforms. Due to the combined influence of only moderate glaciation, small catchment basins,

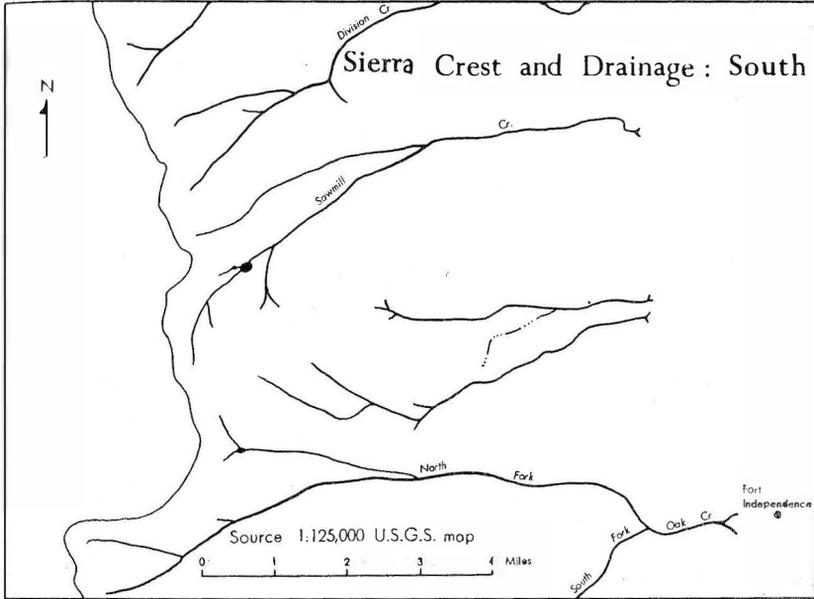


Figure 2—Drainage along the rugged escarpment is confined to a few torrential streams with little lake development

eastern exposed slopes, and exceptionally steep grades, the drainage from this portion of the crest is in a few streams with simple tributary patterns (Figure 2). Runoff is torrential; the streams cascade straight down slope with very few paternoster lakes and almost no calm stretches.

Northern Section—To the north of The Thumb, however, the picture is quite different (Figure 3). The Sierran fault plane is offset several miles to the west, with the vertical displacement apparently distributed along a number of parallel intermediate faults, causing a group of hills and peaks in the intervening area.³ The drainage areas of the streams, from Big Pine Creek northward, are therefore larger than their southern counterparts. But

² Eliot Blackwelder, "Pleistocene Glaciation in the Sierra Nevada and Basin Ranges," *Bulletin of the Geological Society of America*, Vol. 42, (December, 1931).

³ Adolph Knopf, *A Geologic Reconnaissance of the Inyo Range and the Eastern Slope of the Sierra Nevada, California*, U.S.G.S. Professional Paper #110, Government Printing Office, 1918.

what is equally important to the natural drainage is that much of this additional watershed consists of shaded northern slopes. Because of this combination of increased watershed area and more protected slopes, glaciation was of greater importance in these valleys as a landform modifier. In fact, Palisade Glacier, the only remaining glacier in the area under consideration, is located directly north of The Thumb, at a point where the crest has a decidedly east-west trend. The streams in this area have much more intricate drainage patterns with many staircase and paternoster lakes. Rather than cascading down a steep escarpment, they flow more leisurely into lower valleys. The yearly snow crop is more productive due to the shaded

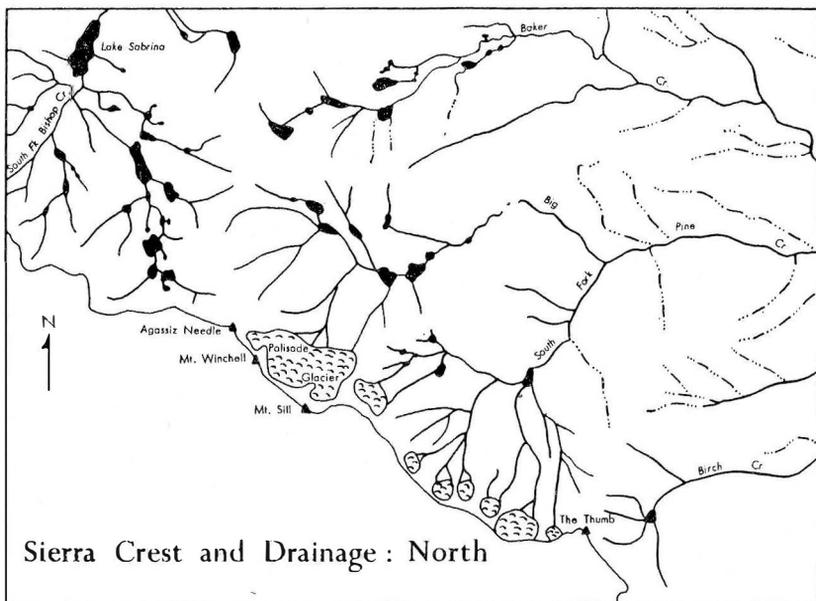


Figure 3—Drainage in the northern section is characterized by a great many lakes and an intricate tributary pattern.

northern exposure, resulting in a heavier, better regulated runoff. Large areas of relatively level land provide ample room for pine forests and many lakes and streams help make this an attractive mountain scene.

These, then, are two altogether different facets of the Eastern Sierra. The drainage patterns, a product of those landform, reflects their great dissimilarity. A comparison of the two maps (Figures 2 and 3) really illustrates this difference. The maps, of nearly adjacent areas, are at the same scale, and all drainage is shown. The dashed lines on Figure 1 indicate their proximity.

RECREATIONAL USE PATTERNS

Let us now analyze the recreational use of the Eastern Sierra in view of these contrasting physical settings. Because of the differences that characterize the two sections of the eastern slope, two different recreational patterns have developed. From The Thumb southward, the eastern slopes

serves basically as a transit area to the high country west of the summits; that is, it is an area that is traveled *through* rather than traveled *to*. However, from The Thumb northward, the eastern slope is itself the destination for sportsmen and vacationers, with a more complete recreational development than that found to the south. While these two functions are not mutually exclusive, they typify the two sections.

Southern Section—There is little along the steep escarpment to attract sportsmen or tourists. The torrential streams can be fished only by proficient anglers; game is scarce; campgrounds are hewed out of moraine-strewn platforms; and the terrain is rugged in the extreme. There are only six public campgrounds and almost no commercial resorts in this area. Just beyond the crest, however, in the headwaters of the westward-flowing Kern and Kings Rivers, is a wild, rocky, alpine region of lakes, streams, and meadows, comprising an extensive area of wilderness. That the southern section of the east slope serves as a transit area for those going into this remote back-country of the High Sierra is indicated by the road and trail pattern. A number of side roads leave Highway 395, which traverses the west side of Owens Valley at the foot of the mountains, and ascend the encarpment via the stream canyons. The trail system consists of a series of short switchbacking trails that lead directly from the ends of the several roads to the passes at the crest. In only a few instances do these roads and trails branch, and only then to offer a choice of routes to the crest rather than leading to east slope destinations. At the crest these eastern approaches connect with the intricate net of trails of the High Sierra. A further indication of the transit nature of this area is shown by the location there of six pack stations that provide animals for trans-crest pack trips.

Northern Section—North of The Thumb the entire complexion of the landscape changes, and so does its recreational use. Rather than being an area to cross enroute to other places, this northern section is itself rich in recreational resources. Because there are large areas of moderate topography, there is adequate space for recreation; game is more abundant; fishing is better; and the scenery is more pleasing. Although only six forest campgrounds are located in the southern section, the area between The Thumb and Mono Lake contain 46 of them.⁴ The numerous lakes and reservoirs in this area, many of which are accessible by road, are renowned for their excellent fishing. Pre-eminent among these is Lake Crowley, a major reservoir in the Los Angeles aqueduct system. As a result a fortuitous combination of cold water, extensive shoreline, and abundant natural fish food, this artificial lake has proven to be an exceptional fishery, providing some of the largest trout on record. Mammoth Mountain, a volcanic peak on the crest, combines an extremely heavy snowfall with long, well graded slopes to make one of the major ski resorts of the west.

Here again, a number of roads leaves Highway 395, which still lies along the foot of the mountains, and enters the range. But these side roads are more numerous than the southern ones, and they branch more frequently. Because this area has so much to offer the sportsman or tourist, the trail network, while still serving to transport hikers and riders over the crest, also distributes them by means of lateral trails to eastern slope des-

⁴ Public Campgrounds, *Inyo National Forest*, mimeographed brochure.

tinations. A further indication of the attractiveness of this area, in contrast to the southern section, is the existence here of a larger number of resorts, motels, and other commercial facilities for visitors. In addition to being in itself a recreation area, this region, as is the case in the southern section, also serves as a gateway to the high country west of the crest, as shown by the location there of nine pack outfits.

CHANGING LOCATION FACTORS IN THE LOS ANGELES MILKSHED*

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The dairying industry of the Los Angeles Basin is one of the most heavily capitalized agricultural industries in the world today. Land values for dairying purposes are commonly about \$20,000 per acre and may reach as high as \$90,000 per acre. The investment per cow, exclusive of land, usually averages about \$1,000 per animal. The herds usually number more than 200 cows per farm on land holdings of about fifteen acres each. Finally, these metropolitan dairies produce milk at a retail price lower than that of the highly-praised West Coast Marine dairying areas farther north, or most metropolitan areas of America's agricultural hinterland.

From this brief introductory description of the Los Angeles milkshed, the indication is that dairying here is nearly unique. The purpose of this study is to ascertain the stability of this form of enterprise. The general approach takes into consideration these principal elements:

1. What factors operable at the time the industry was established exist today?
2. What factors operate to maintain a concentration of the dairy industry within its present location?
3. What factors tend to contribute to a dispersal of the industry?
4. What alternative locations obtain in the surrounding area, and what is the nature of the attraction of these locations?

Prior to World War II Los Angeles dairies were widely dispersed throughout the Los Angeles Basin. Large clusters of dairies were scattered over the Basin¹ in areas such as Torrance, Artesia, El Monte and the San Fernando Valley. During this earlier period much of the feed and fodder was available from the local area which was not occupied by the series of nucleated settlements which dotted the floor of the Basin. At that time dairies usually occupied the less valuable land, that which was not suited to citrus or market garden vegetables. It is only since the population explosion which followed World War II that uncontrolled urban sprawl spread out from Los Angeles, and to a lesser degree from the other larger urban communities within the Basin, to occupy the land to the extent that

* The information from which this paper was developed came from a wide variety of sources. Interviews were carried on with farmers throughout the entire milkshed; transport media, lending agencies, and service companies supplied much useful information, and cost studies prepared by the Milk Producers' Council were of inestimable value. Finally, a critical reading of the paper by Donald Patton of the auditing firm of Fraser and Torbet helped to eliminate errors which may not otherwise have been discovered.

¹ The metropolitan areas of Los Angeles and Orange Counties, roughly centering on the Bellflower-Artesia area will hereafter be referred to as "the Basin," while the other locations indicated on the map (Fig. 1), namely Chino-Ontario, Hemet-San Jacinto, Bakersfield and the Antelope Valley will be classified as the "outlying areas."

it does today. It was this sprawl that filled the interstitial spaces between the population nodes and displaced the scattered dairies.

The result of this displacement was to develop a sort of leap-frogging movement in which those dairies located nearest to the metropolitan centers of population shifted to the periphery of farthest frontier of the producing area. This relocation tended to concentrate the dairies in the vicinity of Artesia and Bellflower. The choice was a fortunate one. Land values were not high since most of the land did not contain top orchard or agricultural soils. Despite the fact that the region was semi-rural, it was within easy hauling distance for the transportation technology of that time. It was near the Long Beach-Los Angeles Harbor for low-cost importa-

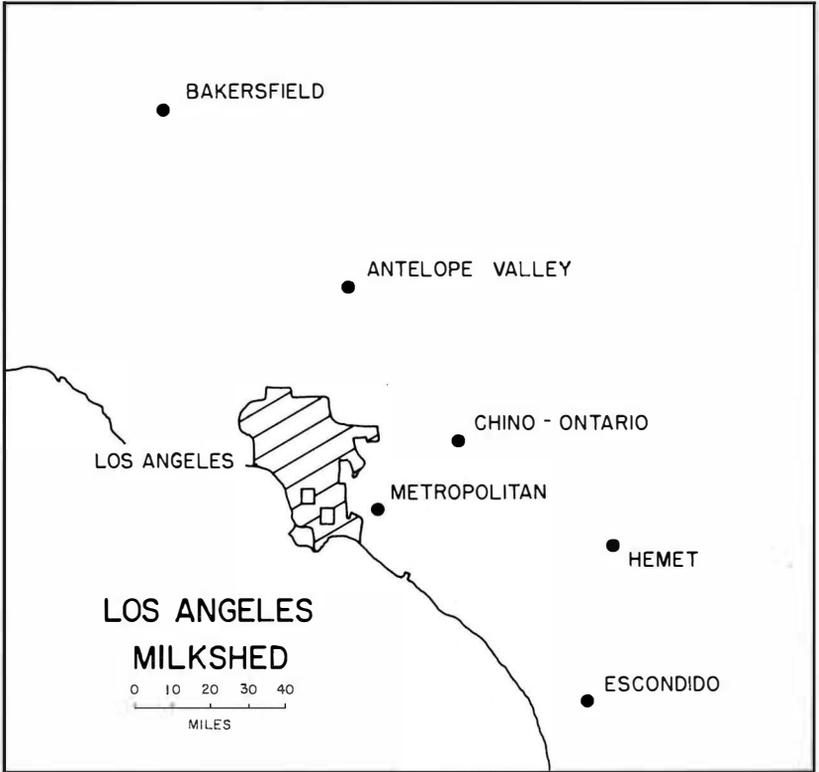


Fig. 1

tion of feed grains and had good access to the alfalfa-growing districts even before the development of the present freeway system. Finally, the tempering effect of the nearby ocean kept temperatures at what were believed to be near the optimum level for dairy production. The effect of this movement of dairies was to create a concentration such as had never existed before in the Basin. The effect of concentration was to make possible an efficient specialization which imparted an increasingly industrial tone to dairy operations.

Although dairying within the Bellflower-Artesia area may be historically credited to fortunate environmental and locational factors, it is now constantly assailed from all sides by forces which threaten to pre-empt the site which it occupies. The tenacity with which it continues to occupy land within what has become an urbanized zone indicates that it comprises a highly competitive and seemingly stable form of land use.

The evaluation of the stability or lack of it in an industry is usually dependent upon the efficiency of the operation of the firm or the advantages that are inherent in different locations. In this study no attempt is made to assess individual firm efficiency. Instead, an attempt is made to establish the differentiation of efficiency with relation to location within the milkshed.

It is within the Basin that dairying most nearly resembles industry in its *modus operandi*. This district has attracted to itself a whole series of specialized services, each of which contributes to the efficiency of the center. Hay and grain dealers, veterinarians, equipment handlers, specialized financing organizations, cattle brokers and a pool of skilled labors are all available within a few miles or a few minutes time.

The need for immediate adjustments toward the area of greatest efficiency is diminished by the fact that prices of dairy products are administered under California milk marketing Laws. However, in an industry with but a few marginal producers, the desire to maximize income may produce the same effect. To quote John Ise, "Man no longer works for bread, but for the jam on bread."

In order to minimize costs and maximize "jam," production usually takes place within the "least cost" location. Any attempt to assess the most desirable location must therefore ascertain what are the major costs, and establish whether there is a differential between the Basin and the outlying areas (Table 1).

Monetary Cost Per Pound of Butterfat Produced²

Grain	\$.39	Labor .....	.18
Hay .....	.35	Herd Replacement .....	.09
Green Feed .....	.03	Milk Hauling .....	.04
Depreciation .....	.04	Taxes .....	.04

A number of minor costs, totalling \$0.14, which seem to have little variation relative to location, are not considered.

Table 1

The highest cost input component for dairy men is grain. This item is used in large quantities in order to maintain the extremely high production. The Basin has a decided advantage in feed costs. Although few of the ingredients of feed are produced locally, the location of the milkshed in relation to the port area makes high quality feeds available at low costs. Copra from the Pacific, milo from Texas, and peanut meal from south-eastern United States, are blended with local cottonseed meal, rolled barley, rolled oats and beet pulp to supply a rich, low cost, mixed feed.

² Milk Producers' Council, *Cost of Producing Market Milk in the Los Angeles Metropolitan Milkshed*, Frazer and Torbet, Los Angeles, 1959.

Since nearly all feed mills are located close to the port, additional transportation costs are charged for delivery of feed to outlying areas. These added costs range from \$.50 per ton at Chino to \$3.00 south of Hemet. This is one clear advantage for the dairies of the Basin area. It can only be offset by dairymen in outlying areas mixing their own feeds and placing more emphasis on locally-produced materials such as barley, beet pulp, or cottonseed meal. Possibly through the greater use of green feeds, more readily available in the outlying areas, this seeming disadvantage may be partially eliminated.

Since hay is a bulky commodity and it is the second highest cost factor in milk production, its acquisition at the lowest possible price is essential to competitive operation. It is only the intense competition and the large market that makes the Basin producers, who are totally divorced from their hay source, able to continue operation. Agriculturists are rarely in a position to take advantage of a truly competitive market. Farmers in most areas tend to be self-sufficient in hay and feed grains. On the other hand, farmers here are in a generally superior position, with excellent credit and an exact knowledge of what their hay requirements will be. Consequently they are seldom placed in a disadvantageous buying position. Furthermore the sources of supply of hay are stable. All hay is irrigated, so drought risks are eliminated. Where it is produced in surrounding desert areas inopportune rainfall rarely adversely affects the harvest. Only occasionally does wind cause extensive damage to the crop of alfalfa, mostly in the Imperial and Antelope Valleys. Specialized carriers move the hay to market and are sufficiently numerous that, even in the short run, there is little or no variation in transportation rates. Supply and demand of hay are usually in excellent balance. The only important outside factor causing price fluctuation is the cyclic increase in beef herds or the increased demand when drought affects the open range.

The existence of a stable market, however, is not limited to the Artesia-Bellflower area. Since the hay producers are located in a semicircle around the entire milkshed, each sector has at least one hay market at which it has the locational advantage.

All hay producers ship to the Basin as this still comprises the major market. Although the Basin does pay a slightly higher price for hay than do the outlying areas, there is a compensation which offsets this apparent disadvantage. The cost of shipping the milk produced from one ton of hay is roughly equivalent to the cost of moving that hay over the same distance. Therefore, the Basin producers, being at the market, neither gain nor lose because of location.

Labor is employed and used in the Basin in a manner resembling that of industry rather than agriculture. A standard division of the work force has been developed in which employment includes milkers, ranch hands, and the owners or managers. The resultant efficiency makes possible the operation of dairies with a higher "cow-to-man ratio" than in areas elsewhere. In 1959 the average was sixty-two cows per man, by 1960 a common figure was ninety, and the target for many efficiently organized farms for 1961 is in excess of one hundred. In most other areas of the U. S. the ratio is commonly about forty. This system is necessary because milkers' wages in the Basin are about \$550 per month, plus fringe benefits and Social Secu-

city. All milkers are members of unions and skilled, qualified relief milkers are available from union headquarters on as little as one-half hour's notice. Most farmers wholeheartedly subscribe to the present system as it has diminished risks due to absenteeism, increased efficiency, and contributed to the predictability of costs.

In the outlying areas the organization described exists to a lesser degree. Although labor inputs have been decreased in the past decade, they are often higher than are those of the Basin. Furthermore, with the exception of Chino, there are no unions and, consequently, no readily available relief milkers. Until there is a sufficient concentration of herds to supply employment for a number of relief men, these districts will be at a disadvantage in this respect compared to the metropolitan dairies.

Very few of the dairymen of the Basin raise their own herd replacements. Since hay costs are too high and land too dear to be used in feeding young stock, fresh cows or springers are purchased from local dealers. Although initially this seems to be an expensive system it has a number of advantages not immediately apparent. The heavy feeding program necessary to maintain high milk production limits the producing life of cattle. Most farmers have a turnover of about 40% of the herd per year, and for tax purposes cows are amortized over a short period. This method allows a much greater degree of flexibility than would be possible were replacements produced on the farm. Each farm has "shipping rights" for a given amount of milk, and surplus milk over this amount must be sold at a price far lower than that paid for Grade A. By purchasing cattle the producer can balance very accurately the supply with the demand, and with the contract he has with his processor. Although this system is necessary within the Basin, it does increase the cost of cows.

Dairymen in outlying areas can, with their larger land holdings, supply their own herd replacements rather than incurring purchase and freight charges from Utah, Northern California or Idaho. However, as land costs rise in the outlying area, the Basin system occurs more often and Chino-Ontario now commonly follows that method.

Taxes are also subject to area differentiation and are a cost factor in dairy operation. Although land values in this part of the Basin are on the order of \$15,000 or more per acre, specialized zoning of dairy cities has restricted assessed value to about one-third of this amount. By means of zoning, residential tracts have been precluded, and at present these zoned cities have a heavier cattle than human population. One of these areas, Dairy Valley, has 8.7 square miles, 3,505 people, and 85,000 cows. Cypress occupies 5.5 square miles, has 1,723 people, and 13,500 cows. Dairyland occupies 2.5 square miles, has 620 persons and 11,000 cows. However, since the re-zoning of 400 acres in Cypress for residential use in 1960, estimates are that the city will gain 5,000 persons per year for the next five years.³

In addition to the real estate tax, property taxes are assessed on cattle and equipment. Since taxes are proportionate to costs of local government, increases in residential occupancy, without corresponding growth of commerce or industry, would have the effect of placing a disproportionate

³ *Los Angeles Times*, Oct. 23, 1960, Sec. J, p. 18.

burden upon Basin dairymen. Those outlying areas which are still rural in nature, therefore, do have a slight tax advantage as a result of lower local government costs.

In addition to the traditional cost items, there are a number of other factors which differ with area. Dry lot dairying in no way resembles that rural occupation elsewhere. Beautiful cattle do not wander along tinkling brooks in sylvan glades and bosky dells. Rather, they stand, rain or shine, cheek by jowl, in multiple corrals each containing 30-60 cows, and they generate flies and odors. Flies become more difficult to control as the use of DDT tends to result in chemical residuals, which are not permissible by law, appearing in the milk. Odors *may be* controllable, but no satisfactory method has yet been found for controlling odors emanating from cattle held in close or cramped quarters.

Under these conditions large-scale residential and cattle populations are not compatible. Nuisance suits have already been instituted in some places and sentiment in general is strongly against those who farm in the city. Many city farmers are constantly made to feel as if they are pariahs in their own communities. This is not the type of relationship that prosperous dairymen wish to have with their fellow citizens and it is not the kind of acceptance they receive in rural areas of the outlying districts.

The key to contraction or expansion of individual dairy herds is the relationship between the farmer and the processor. Each farmer sells his milk to a given processor in accordance with a contract. This contract guarantees the farmer a market for his milk within the range of the contract stipulation. The amount of milk the dairyman may ship to the processing company comprises his "shipping rights."

The shipping rights system is necessary for two reasons: first, milk is such a non-storable commodity and is produced in such great volume that, had he no guaranteed market for Grade A milk, the farmer would be completely at the mercy of the processors; and, second, fixed costs of operation in the Los Angeles milkshed are high enough that the farmer would be quickly bankrupted were he to produce factory or Grade B milk for cheese, butter, or canned milk manufacture.

Most commonly there is a 10% surplus of fluid milk available in the Basin and surrounding areas, thus any individual farmer is essentially expendable as far as the processors are concerned. If in any way the farmer fails to meet the requirements of his contract, his shipping rights may be cancelled on 30 to 60 days notice. It is virtually impossible for a disenfranchised dairyman to negotiate a new contract within this period of time. Therefore, with no market for his milk and faced with continuing high fixed costs, the farmer who has lost his shipping rights must liquidate his holdings immediately.

This life and death power which the processor holds over the farmer can control the location of the dairy industry. The most common cause given for contract cancellation is high bacteria count or chemical residual in milk. Since both these factors are generally more difficult to control where there are a large number of cattle per square mile, the areas outside the Basin are more attractive than those within it.

Finally, the shipping rights are among the most valuable assets of the dairy man. They may not be *legally* bought and sold, but their value is so

high that in some cases they may become the object of some form of exchange and rights may be granted to a new shipper who has recently purchased land outside the Basin at high prices. Reportedly, some processors do own land within the Los Angeles milkshed, and the prices of such land could essentially include shipping rights.

SUMMARY

The previous discussion would imply that the dairymen of the Basin and the outlying areas are in an approximately equal economic position. Despite the encirclement of the present Basin area by residential and commercial establishments, its prosperity has never waned. Dairying is still as profitable within the Basin as it is outside. However, its future is not assured. At present, zoning laws have given it temporary security in places such as Artesia, Dairy Valley and Cypress. As land values increase, the farmers' resolve to remain, which was once strong, tends to diminish. Dairyland is considering re-zoning which will permit the development of a part of the area as a commercial and industrial district. Although this may be more compatible as a land use system with dairying than is residential use, it does introduce another element. As these industrial groups move into the dairy area, they increase the pressure which can be applied toward the easing of residential and other restrictions. As a consequence they can exert additional influence on dairies.

The dairymen are able to withstand only so much pressure. They may be able to legally occupy the areas which they now hold, but the point will come here, as it did earlier near the metropolitan centers, in which the game is not worth the candle. The liquidation of holdings is simplified by high value of the land for other purposes, and since the \$15,000 or more per acre may not be excessive for industry, it is beyond the economic rent limitations for agriculture. Since dairymen generally consider themselves to be farmers as well as business men, and since the sale of their present holdings will finance the re-establishment of their operations elsewhere and still leave a profit, these Basin producers may elect to move.

The present indication is that a continued shift will be to Chino-Ontario, the area which is nearest to the present center and still outside of the urbanized zone. This movement is already well under way, and that section is rapidly acquiring the advantages of specialization without the disadvantage of over-concentration.

As presently constituted the dairy industry of California is, within limits, a footloose industry. It is not now tied to soil types, rainfall, growing season or even, importantly, temperature. The cows stand on a slab of concrete, and to them are brought varieties of food and from them are taken huge quantities of milk. It appears that the inexorable laws of psychological and comparative advantage will, within the next few years, relocate that slab. To a limited degree, dairying should pre-empt land in accordance with Von Thunen's principle. Due to the elongated shape of the Southern California megalopolis, a number of specialized nodes are appearing. However, the advantages of specialization are now so evident, the location so favorable, and the head start so imposing, that the Chino-Ontario district is on the way to becoming the dominant dairy area of Southern California.

SAN FERNANDO VALLEY: TWO HUNDRED YEARS IN TRANSITION

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As San Fernando Valley approaches its 200th year of modern history, there are indications it is finally approaching urban maturity. Prior to this time the area has witnessed successive stages of settlement and land use, which, like the flush of wild flowers on a spring hillside, have come and gone, leaving behind only weathered vestiges to signal their former presence. This report briefly reviews the periods of human settlement in the valley since it was first visited by Europeans and focuses attention on the present as an integral part of Metropolitan Southern California.

In the year 1769, Gaspar de Portolá led a party of Spanish explorers north up tortuous Sepulveda Canyon and over the Santa Monica Mountains, dropping into a broad, grassy valley rising gently to the north, dotted with massive oak trees. As seen by these early explorers, the Valley of Encinos, as it was first named, was a gently undulating, triangle-shaped, structural valley, 235 square miles in size, surrounded by rugged hills and mountains. Crossing from northwest to southeast was an intermittent stream which exited from the valley at a narrow gap between hills, a gap later to become the major transportation route for the region.

Modern settlement in the valley began in 1784 with the establishment of Rancho San Rafael by Corporal José María Verdugo, in the present Burbank-Glendale area.¹ In 1791, Mission San Fernando, founded in the gap between Mission San Gabriel and Mission San Buenaventura, was awarded nearly all the remaining unalienated valley lands.² Before long the Franciscan missionaries had attracted hundred of neophytes, managed large herds of sheep and cattle, and were successfully growing crops. Wool textiles, soap, leather goods, tallow, tile, and wine were the principal items produced. For a time Mission San Fernando, along with the other twenty missions in California, was a principal supplier for military posts in this distant Spanish province.

The Mission's decline began in the Mexican period when its lands were secularized in 1834 and only the church was placed in the priests' hands. Later the lands were sold to raise revenue for an abortive struggle against the advancing Americans. By 1875 the former mission lands had substantially passed to American owners, with the north and south halves going to separate land associations.³ In the early years, sheep and wheat shared most of the valley, but the founding of the town of San Fernando in 1874 was soon followed by plotting of Pacoima, Burbank, Chatsworth, and Lankershim (later named North Hollywood).

It was in the 1880's that the Valley, now named after the mission, came to be known far beyond the limits of California through the efforts of real estate speculators who sought to entice settlers with notices of cheap

¹ Bancroft, H. H., *History of California*, Vol. 1, 1542-1800, San Francisco, A. L. Bancroft & Co., 1884, p. 661.

² Engelhardt, Zephyrin, *San Fernando Rey: The Mission of the Valley*, Chicago: Franciscan Herald Press, 1927, p. 47.

³ Keffer, Frank, *History of the San Fernando Valley*, Glendale: Stillman Printing Co., 1934, p. 49.

land and a superlative climate. Railway fares from the east were set at a ridiculously low rate and visitors were welcome at elaborately-planned field days. Although many came, the frenzied land boom of 1888 ended in sudden collapse and a temporary depression, but not before the foundation had been laid for the third era of valley occupance—the town and fruit farm period.

By 1900 orchard farming had spread along the margins of towns and began filling the open spaces. To the southwest of San Fernando grew oranges and to the northeast olives. Peaches and apricots were in the North Hollywood area and walnuts in the west valley. Vegetable farms were scattered here and there in response to urban demand. The Great Owens Valley aqueduct soon brought water into the valley to supplement underground supplies.

The end of World War I found the valley mostly under crops or in residential communities, with the major thoroughfares seen today already surveyed. Suburban lines of the Pacific Electric Railway were extended from Los Angeles to San Fernando and Van Nuys. By this time the settlements of Sherman Oaks, Encino, and Woodland Hills had grown up along the southeast margin, and Canoga Park, Reseda, Northridge, and Granada Hills filled in most of the remaining west Valley. These, and other settlements, excepting San Fernando and Burbank, had been incorporated into Los Angeles City between 1913 and 1915. At this time the Valley, with a population of about 50,000, could be characterized as rural. Each of the dozen or so residential communities was surrounded by farmlands, with principal outside ties gained through major and suburban railway lines, particularly with Los Angeles, but also with northern settlements.

Hints of a change in occupance began in the east Valley when in 1928 Lockheed Aircraft Corporation, now a strategic manufacturer of military and commercial airplanes, located its plant in Burbank. As the company grew through the 1930's, allied industries clustered about it, adding their demand for labor to that of Lockheed's, until ultimately the east valley came to be associated almost exclusively with aircraft manufacturing. Orchard and vegetable farms adjacent to Burbank and North Hollywood gave way to residential land use as an urban picture began to emerge.

Meanwhile, the west Valley, encompassing all the area beyond Van Nuys, and San Fernando, remained mainly rural in character. The suburban railway line from Los Angeles penetrated only to the community of San Fernando, and, although the through railroad passed beyond that town, it soon turned into mountains and did not furnish a connection with the west Valley. Another line eventually crossed the entire valley, exiting at Chatsworth, but this offered no easy access to the outside. Roads were commonly interrupted by streams and gullies, and only two or three were passable throughout the valley.

What industry there was during the time between the two great wars sprang from agriculture. In Sylmar, north of San Fernando, olives were processed; immediately southwest of San Fernando oranges were picked for shipping, and farther southwest around Northridge-Reseda walnuts were the export commodity. Dairy and poultry farms were situated in the southwest limits.

But with the advent of Hollywood and the cult of cinema personalities, a new era began, that of suburban San Fernando Valley, identified particularly with the western half of the basin. The earliest migration occurred down the north slope valleys of the Santa Monica Mountains; but before long the earthy pastoral life lured many celebrities across the valley and soon formerly pure farm communities included some members of the Hollywood industry. Universal, Warner Bros., and particularly Republic movie studios situated themselves along the northeastern flanks of the Santa Monicas, within easy reach of a still undefiled landscape in the peripheral mountains where western sagas could be filmed.

The years from 1930 to 1940 in the west valley, indeed, saw the height of the suburban period. In 1930 Valley population amounted to 78,000, with perhaps one-quarter in the western portion.⁴ By 1940 with population at 155,000 the proportion approached one-third. A bucolic scene, mingled with large livestock-breeding estates, imparted an aura of rural serenity that was to characterize the valley through the years of World War II, idealized in song and story.

This then was the picture in San Fernando Valley at the close of World War II in 1945: population stood at about 230,000; in the east Valley, largely around Burbank and North Hollywood, aircraft manufacturing and associated industries dominated the landscape as a sort of industrial extension of the Los Angeles basin, and in the west Valley a rural scene prevailed between the residential and market towns and literally no manufacturing was to be found.

The Valley's current era of explosive population growth and land use change began immediately following the war. In the five-year interval 1945-1950 population nearly doubled, going from 230,000 to 403,000, an rate of increase equal to 2,880 persons per month, a rate somewhat above the natural increment. Between 1950 and 1960 immigration jumped to 3,650 per month. Since this represents about 720 families per month, it is not surprising that the most apparent Valley change is in the residential picture. For example, since 1949 not less than 125 new subdivisions were surveyed each year. The highest number was 401, this in 1956. New dwellings averaged nearly 12,000 annually, the peak being 17,000 in 1953-1954. A few minutes drive, particularly in the west Valley, are enough to grasp the meaning of these data. Tract followed tract where orchard land spread before. There are the drab, the faceless houses; there are also the expansive properties trimmed by neatly appointed gardens; and the number yet to come is awesome.

But while residential land use grew several-fold in the years 1950-1960, industry, too, spread across the Valley, changing in character and portent as it entered. To Van Nuys, came Lockheed's Missile and Space Division and the Marquardt Corporation; to Northridge, RCA's West Coast Missile and Surface Radar Division; and to Canoga Park, North American Aviation's Rocketdyne Division and the Thompson-Ramo-Wooldrige Laboratories. And into the Simi Mountains nestled Rocketdyne's Propulsion Field Laboratory to rend the still west Valley air with the

⁴ Security First National Bank, Research Department, *The Growth and Economic Stature of the San Fernando Valley*, 1960, Los Angeles; published by author, September, 1960. p. 8. Statistical data for the remainder of this brief historical review are taken from this study.

thunderous blast of ignited rocket power under test. In other Valley areas Atomics International of North American Aviation, Bendix Corporation, Radioplane of Northrup Corporation, Chevrolet and Fisher Body of General Motors Corporation, joined the older industries, By 1960, there were in the Valley, 92 enterprises employing 100 or more persons and 12 with 1,000 or more. Of these, 40% were in electronics, and defense research and development. The San Fernando Valley had by this time expanded beyond aircraft manufacturing to the field of advanced space engineering. The leading manufacturing communities were Burbank, Van Nuys, Canoga Park, and North Hollywood. Employment in 1960 in manufacturing was approximately 80,000 and total employment was about 240,000. In addition to the 5,000 acres then in industry, another 3,000 were zoned but unused, an appreciable reserve for future growth.

Meanwhile, intra- and inter-regional ties had been strengthened. Although numerous interruptions persisted, most roads through the Valley were paved by 1960.

But the most striking feature in the transportation scene by now are the inter-regional freeways that will eventually lace through the Valley. Now about one-third completed, freeways to total some 80 miles in length will cross east-west and north-south and provide rapid transportation to most places within the Valley and connect it with Los Angeles and the Coast.

There are many qualities of San Fernando Valley which distinguish it as a region of conspicuous consumption. It is an area of high income. For example, in 1959 total income was \$2.6 billion, higher than the income in each of 18 states. Estimated per capita income was \$3,175, compared to \$2,926 for Los Angeles County, and well above the national per capita income. Median family income was \$7,091, higher than the county's \$5,818, and topped only by Beverly Hills at approximately \$11,500. The number of automobiles on the Valley streets similarly attests to affluence. Forty-five percent of the families own two or more cars. In the county 30% of the families have more than one car. The ultimate symbol of wealth, however, is the swimming pool. In the two-year period 1959-1960, permits for nearly 6,000 residential pools were issued, and by all indications pool construction in 1961 continues at an accelerated pace.

What of the future? Population in 1960 stood at 840,000. Estimates for 1970 are for 1,250,000 people and for 1980, 1,600,000, about double the present number. This would presume complete urban residential build up, with probably an increase in multiple-dwelling units. In the period 1951-1956 multiple dwellings represented 20% of all houses built. In the period 1956-1960, this figure increase to 35%. There is, in any case, no slackening in the population growth and building pace in the San Fernando Valley. Although the region has changed markedly in the past 10 years, the next 20 appear to promise still greater change.

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ROBERT W. DURRENBURGER

San Fernando Valley State College

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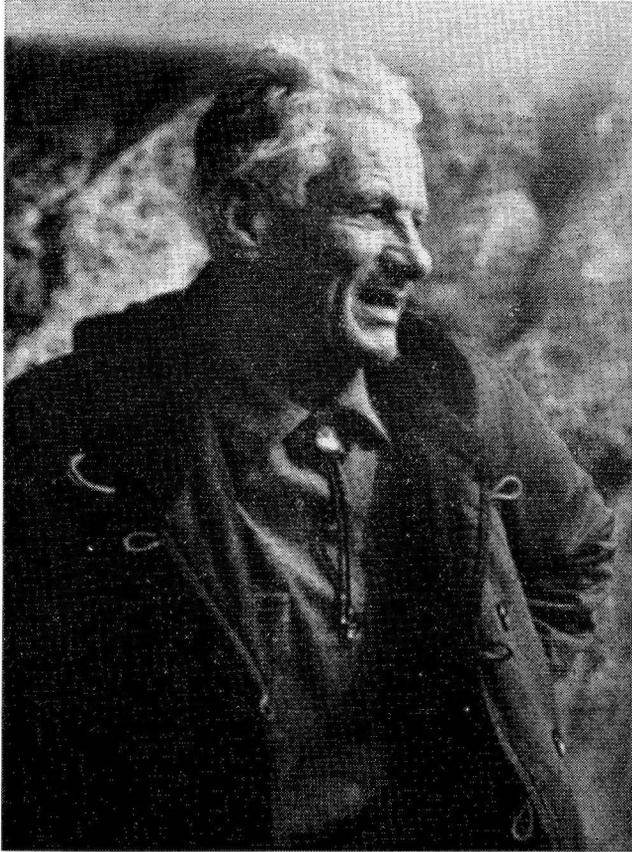
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JOHN ERNEST KESSELI

JOHN ERNEST KESSELI: AN APPRECIATION

On May 23, 1962, John E. Kesseli celebrates his sixty-seventh birthday. The following month he retires from active teaching on the faculty of the Department of Geography at the University of California, Berkeley.

He is the last to step down of the triumvirate Sauer, Leighly, and Kesseli, whose strikingly individual personalities and vigorous scholarly interests have given Geography at Berkeley its character during the past thirty years. John Kesseli has been an exacting and challenging teacher and adviser. He has focused his attention on a rigorous and disciplined training of students, both graduate and undergraduate.

As one former student, Edwin Hammond, has put it, "From John Kesseli one received vigorous instruction in three closely related principles: that the collection of scientific evidence must be thorough and unbiased; that nothing is true simply because someone said that it is true, and that good scientific answers are usually hard to come by. He stressed the value of skepticism and healthy heresy. He emphasized the importance of clear, effective, and honest reporting. He opened up almost endless prospects for research by making clear how few things are really well understood or proven. He taught the value of discipline in scholarship without getting it mixed up with the quite different notion of authority."

For ten years, from 1946 to 1956, he served as graduate adviser in the department. His often blunt, yet wise and deeply humane, counsel made a profound imprint on many students. Between 1948 and 1959 Kesseli was in charge of 16 of the 36 M.A. theses completed at Berkeley, and he directed five doctoral dissertations in geomorphology. It was his manner to work page by page over each manuscript with the student by his side, laboriously, until the job was done right. He permitted no fuzzy thinking or insufficiently supported conclusion to go unchallenged. His critical, analytical mind was the perfect whetstone for the serious student who not only learned to think rigorously and logically, but also acquired a new respect for the English language.

For most of his career at Berkeley Kesseli has been in charge of foreign language training and examinations for Ph.D. candidates. For this task he was uniquely equipped. His was a private tutoring system, demanding of his time, and (despite his disclaimers) productive of results.

He labored endlessly on his courses. They were tough but popular. For many years he taught the large introductory physical geography course and his mimeographed syllabus continued to be used after he turned the responsibility over to younger members of the staff.¹ His regular classes

¹ *Outline of Physical Geography*. California Book Co., Berkeley, 1939. 102 pp.

included Analysis of Land Forms, Map Reading, Photogrammetry, a Saturday field course, and, occasionally, Cartography. For many years his Analysis of Land Forms was considered by the graduate students a "make or break" course. An "A" from Kesseli was the best evidence available that a student had the stuff to continue on toward an advanced degree.

Born in Paris, a Swiss citizen, Kesseli spent his boyhood in St. Gallen, Switzerland. Here his love for glaciated country, later transferred to the Sierra Nevada, first developed. His first publications were on Alpine tectonics and on moraines.² He was attracted to physical geography and studied at Halle, Munich and Lausanne, especially with the geologist Johannes Walther and the geographer Otto Schluter. He also taught in St. Gallen schools and in Lausanne. In 1930 he came to the United States, teaching for a year at the Thatcher School for Boys at Ojai, Ventura County, before going to Berkeley to resume his graduate studies in Geography. In 1932 he was appointed to the Berkeley staff with special responsibility for geomorphology. His doctorate, based on detailed field studies of glaciation in the Mono Lake sector of the Sierra Nevada, was awarded in 1938. Substantial portions of this meticulous job were later published in the University of California Publications in Geography,³ while shorter articles deriving from this field work appeared elsewhere.⁴

It was in these years that he produced his classical, widely-quoted paper on the concept of the graded river, articles on soil slips in the Central Coast Ranges, a revision of the Köppen climatic classification for California,⁵ his lucid, English-language summary of the studies of slope development by Walter Penck and Sieghard Morawetz.⁶

The war years were spent in Washington, working with Army Intelligence in the Pentagon. His decision to come back to Berkeley in 1946

² "Neuere Ansichten über die Tektonik der subalpinen Molasse zwischen Linth und Rhein," *Jahrbuch der St. Gallischen Naturwissenschaftlichen Gesellschaft*, Vol. 61 (1925), pp. 147-169; "Die Jungmoränenstadien in den Quertälern der st. gallisch-appenzellischen Molasse," *Ibid.*, Vol. 62 (1926), pp. 56-80.

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must have been a difficult one, for he had won many friends and high respect in Washington intelligence circles and had been strongly urged to stay on there.

A growing concern for a more geographical geomorphology was expressed in his 1950 presidential address before the Association of Pacific Coast Geographers when he spoke out strongly against deductive or explanatory classifications of land forms and urged instead improved empirical descriptions of geomorphic landscapes.⁷ Another address, in this period, before the American Society of Photogrammetrists also took for its theme the importance of good geomorphic description and the role that aerial photography might play in it.⁸

In later years his interests have shifted increasingly toward teaching, including the activities of the California Council of Geography Teachers and the improvement of his own courses, especially his favorite, the Geography of California. That the latter, despite much urging, was never rendered onto paper is typical of Kesseli's attitude and philosophy. A perfectionist, he has always been unwilling to associate himself with what he considers to be inadequate work, that is, anything less than the very best. Despite the extraordinary extent of his travels in his adopted and beloved state, he has insisted that he does not know enough about California, especially its economic geography, to do the sort of job that needs to be done. However, he knows California as few men have or will. The state has been his first love, and although he has urged his students to get out into unfamiliar environments and cultures, he has always focused his own attention closer to home.⁹ For this circumstance a generation of California geographers can hardly be other than grateful.

Publication of the following supplement to *The California Geographer*, a modest sort of *Festschrift*, composed of papers contributed by his students, has been made possible by financial contributions of more than forty former students and friends who hope that he will accept the compliment and expression of affection that it is intended to represent.

THE KESSELI FESTSCHRIFT COMMITTEE

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⁷ "Geometric Landscapes," *Yearbook of the Association of Pacific Coast Geographers*, Vol. 12 (1950), pp. 3-10.

⁸ "Use of Air Photographs by Geographers," *Photogrammetric Engineering* (Sept. 1952), pp. 737-741.

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LAND FORM GEOGRAPHY AND LAND FORM DESCRIPTION

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In his presidential address before the Association of Pacific Coast Geographers in 1950,¹ John Kesseli vigorously challenged geographers to discard their traditional approach to the study of land form and to replace it with "a geomorphology a geographer can really use." Classical geomorphology, he declared, "stresses the geologist's interest in diastrophism and in evolution during the geologic past," and does not reflect the geographer's interest in the use of the land, "which demands that principal attention be paid to lithology and to the landforms of today." He recommended that geographers embark upon "an intensive search for regions of similar and of different landform types." He further advocated "clear empirical descriptions of these geomorphic landscapes, descriptions which provide a lucid picture of the scene upon which the human drama is to be unfurled."² Thus he called for a study almost wholly descriptive, and much of his address dealt with the process of empirical description itself, its values, its difficulties, and the steps needed to overcome these difficulties.

Kesseli's plea was not a solitary and unique cry, nor were the thoughts that produced it wholly without antecedents. Dissatisfaction with traditional geomorphology was then and is now widespread among professional geographers, being perhaps most expressively, if mutely, manifest, in this country at least, in the dwindling number of geographers choosing land form study as a field for research specialization. Specific, constructive, and public expressions of opposition to the traditional approach have been relatively few, though a significant number have been important and influential. Of these, in addition to Kesseli's address, two seem especially pertinent to a discussion of the concept of a geography of land form and the place and purpose of description within it.

The first of these is R. J. Russell's presidential address, delivered before the Association of American Geographers in 1948.³ Here we have a prominent geomorphologist issuing a strong indictment of the classical approach to the study of geomorphology on the grounds that it is unrealistic, too much concerned with structure, process and time, and not sufficiently attentive to the question of "what, where, and how much." The address has attracted wide attention and provoked considerable discussion among American geographers. Kesseli, speaking a year and a half later, used Russell's papers as a point of departure, underscoring his criticisms of classical method, but proposing a distinctly different approach to the problem.

In *Perspective on the Nature of Geography*, appearing in 1959,⁴ Richard Hartshorne added his voice to those of Russell and Kesseli in main-

¹ John Kesseli, "Geomorphic Landscapes," *Yearbook of the Association of Pacific Coast Geographers*, XII (1950), pp. 3-10.

² All quotations *Ibid.*, pp. 3-4.

³ R. J. Russell, "Geographical Geomorphology," *Annals of the Association of American Geographers*, XXXIX (March, 1949), pp. 1-11.

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taining that for geographical purposes the study of land form concentrate upon the facts that may be construed as geographically significant. Even more valuable is his lucid analysis of the nature of topical studies in geography, for it is from these considerations that a logically-conceived geography of land form may be constructed, parallel to other topical geographies, some of which are already soundly established and broadly developed.

Hartshorne characterizes a topical subdivision of geography as one in which the areal variation of a limited group of closely related elements "is studied in terms of the interrelations of its elements among themselves and with those of other areal features or elements." By this concept the geography of land form would be the study of the place-to-place variation of the land's surface form in its relationships to the distribution of other phenomena, as a part of the total significant variation of areas.

The center of attention in such a study is the nature and pattern of variation of existing surface configuration. The aspects of land form to be stressed are those that are most significantly related to other geographical elements. The variation of these aspects are to be studied not only for their own sake, but in terms of their functional interrelationships with those of other phenomena. Studies of the genesis of land form variation lie in the zone within which the weight of emphasis passes from the chorologic science of geography to the systematic science of geology. They have a distinct geographical flavor, however, if they are concerned with some part of the actual pattern of variation of existing land form, are directed toward the understanding of that existing character, and emphasize those aspects of the surface that are significant in the total variation of the areas of which they are a part.

All three of these writers have emphasized the importance of careful factual description of the land surface as it varies from place to place, and all have emphasized the importance of centering attention upon those characteristics of the surface that contribute most significantly, in the eyes of man, to the totality of areal character. Kesseli's particular contribution was to stress the importance to geography of the empirical description of land form, which he perceived to be in itself an arduous task. It is the purpose here to develop further the function and the most useful methods of description in a geography of land form that is conceived along the lines sketched in the preceding paragraph.

DESCRIPTION IN THE GEOGRAPHY OF LAND FORM

The traditional core of the discussion of method in land form description is, "shall the description be empirical or shall it be explanatory?" This well-worn argument is taken up again here for two reasons: (1) that the explanatory case has received a disproportionately large share of space for several decades, and (2) that it seems that part of the inconclusive jousting has arisen from certain misunderstanding concerning the place and purpose of descriptive analysis, especially in geographical study.

Traditionally the advocates of genetically-oriented description have rested their case upon three arguments: (1) that explanatory description is more satisfying to the natural curiosity of the student, who wants to know the "why" of things; (2) that description organized on a genetic basis has a higher scientific status, because it considers cause and effect, not merely characteristics; and (3) that by using genesis as an organizing

principle description is made more systematic and less repetitive and is able to convey a more complete picture with fewer words. These points were offered repeatedly by W. M. Davis in his effective and authoritative style,⁵ and, like much that he wrote, became accepted as doctrine and have been quoted and paraphrased with remarkable frequency.⁶

The proponents of empirical description have maintained chiefly (1) that an explanatory description can be no more accurate than the genetic theory upon which it is based and no more complete than the genetic understanding of the surface being described; and (2) that an explanatory description is actually an explanation, and not properly a description at all. To these arguments Kesseli, supported by Hartshorne and others, has added the point that the functional significance of the terrain is based upon actual properties of the land surface, and not the way in which the surface developed.

In the remainder of this paper it will be the contention (1) that the arguments just presented in favor of empirical description are sound; (2) that there are yet other significant points in favor of empirical description based in part upon the function of description in geographical method; and (3) that the principal arguments advanced in favor of explanatory description are in part irrelevant, in part based upon a faulty conception of the purposes of description, and in part unsupported assertions of faith.

In the introduction the case was made for a geography of land form that, at its core, is concerned with the existing pattern of land variation as a component of the significant variation of areas and with the relations of the areal variation of land form to that of other geographical phenomena. It seems unavoidable that a first step in any study so oriented must be a systematic inventory or descriptive analysis of what is actually there, the character of the existing surface. This preliminary analysis, undertaken for the benefit of the investigator himself, is the first of two principal places in which descriptive analysis necessarily appears in studies of the geography of land form.

It is almost inconceivable that this "investigator's description" should be compiled on any but an empirical basis. If the study is investigating land form as something that affects the variation of other physical elements or as something evaluated or utilized by man, the necessity of an initial empirical analysis seems patent. It is the existing land form, not its history or mode of development, that is directly significant in these functional relationships. Relations of climate or agricultural land utilization to the land form are relations with a surface geometry and with (largely) surficial materials, not with developmental sequences or sculpturing agencies.

In a geographically oriented study in land form genesis, to use explanatory description at this stage would be to answer the questions before they have been asked, that is, to imply the genetic relationship before they have been established by the interpreter's study that is to be made. Admission of genetic concepts at this stage is likely to prejudice the investigator's view of the problem in such a way that he readily sees and considers those features that fit into the assumed system of genetic theory while overlook-

⁵ Note especially "Methods and Models in Geographical Teaching" in: W. M. Davis, *Geographical Essays* (Boston: Ginn and Company, 1909), pp. 193-209.

⁶ Cf: Kirk Bryan, "The Place of Geomorphology in the Geographic Sciences," *Annals of the Association of American Geographers*, XL (1950), pp. 196-208.

ing or subordinating those that do not fit the anticipated pigeon holes. A geomorphologist who is committed to a strongly cyclic theory of erosional development, for example, makes much of those bits of bench, shoulder, and flat that bear upon his conception, but may give little attention to the valley sides and rolling upland slopes that occupy the majority of the area. Both Russell and Kesseli have noted this danger and have called for realistic description as its antidote.⁷ If the problem is to explain what is there, let the first task be to find out and set forth in systematic, balanced and unbiased fashion what is *in fact* there. It is by this step that the problem becomes defined. One may at this point venture the opinion that a slighting of the gathering of unbiased empirical observation data has been a major factor retarding real progress in geomorphological theory and favoring the growth and maintenance of the elaborate and stultifying structures of hypothesis that both Russell and Kesseli condemn.

The second place in which descriptive method comes to the fore in a geographic study of land form is that in which the surface is finally described for the benefit not of the investigator but the reader. Here the problem is chiefly one of communication; to convey effectively to the reader an accurate and useful portrayal of the land-form.

It seems clear that it is this second descriptive phase, and not the first, to which the arguments in favor of explanatory description are intended to apply. For if applied to the preliminary analysis, certain of the points become irrelevant or absurd. That concerning satisfaction of natural curiosity, for example, does not apply, for it is from the facts of primary description that many of the questions arise. And since initial observation of fact is basic to nearly all scientific investigation, the gathering of fact in this particular field can hardly be labeled unscientific. As applied to the second descriptive phase, however, the arguments can be meaningfully discussed. Evaluation of them demands an understanding of the purpose for which the description is composed, and it should be remembered that we are here concerned with geographical purposes.

Following the concepts outlined earlier, it will be useful to consider two types of studies that are geographical or at least geographically flavored: those involving the land form as something functionally related with other phenomena in areal variation, and those genetic studies centered upon the explanation of significant aspects of land form variation.

For either type of study it may be argued that the first two points advanced in advocacy of explanatory description (that it is more satisfying to the curiosity of the student and that it has a higher scientific status) are in considerable part irrelevant and are based upon a misunderstanding of geographical purposes. A description does its job and possesses scientific value if it conveys effectively to the reader the observed facts that are the very basis of the inquiry at hand.

If the study treats of the functional significance of land form, the bringing of genesis into the picture simply introduces irrelevancy and obscures the relationship involved, for as previously mentioned it is through characteristics and not developmental processes that land form is functionally significant, except in certain situations in which the surface is undergoing unusually rapid change.

⁷ Note especially: Russell, *op. cit.*, pp. 4-8; Kesseli, *op. cit.*, pp. 4-5.

If the study deals with the genesis of existing variation, one may object if the only description offered to the reader is an explanatory one, for in that event the reader has no opportunity to visualize in unbiased form the landscape that is being explained nor to judge fairly the adequacy and validity of the interpretation provided. For the genetic description is perforce itself an interpretation. Davis' statement that "a genetic classification of geographical forms is, in effect, an explanation of them"⁸ is a more cogent argument *against* the substitution of explanatory for empirical description than *for* it.

An explanatory description might however be usefully introduced in a geographically oriented study of land form genesis in the form of a summary toward the end of the interpretative section. At that stage it might well prove interesting and effective to restate the initial empirical characterization of the surface form in explanatory terms, but only as a device to help sum up the genetic conclusions and to make clear that they encompass the characteristics that originally demanded explanation.

But what of the argument that only by the explanatory approach can conciseness, system and clarity be brought to description? For all the logical arguments that can be advanced in its favor, is empirical description really unequal to the task?

System in any expository presentation requires the use of some sort of organizing principle, but genesis is not the only such device available. Function, for instance, is an equally valid one. Another is to hold to inherent characteristics, resolving the complexity of the phenomenon into elements, component parts or attributes that can be characterized separately. This a familiar scheme, regularly utilized, for example, in the description of climates, plants, and, to an increasingly exclusive degree, of soils. Indeed at the moment land form description stands almost alone in its stubborn adherence to a genetic rather than a component-characteristic organization. Possibly this slowness to venture into empirical description stems in part from the fact that land form data are not normally assembled in specific or numerical form, element by element. However, they can be collected in such form, and numerous examples are already available. The literature of morphometry is extensive, though thus far a disproportionately large number of the properties selected are useful only to highly detailed studies of small areas.⁹ Arthur Strahler and his associates have assembled and experimented with an especially large collection of characteristics and indices that are highly useful in the systematic description of drainage basins.¹⁰ Various others have suggested characteristics applicable to more varied styles of terrain.

In earlier essays the writer has suggested that the characteristics of land form can probably all be grouped under the general headings of (1) slope or inclination, (2) surface materials, (3) dimensions, and (4) arrange-

⁸ W. M. Davis, *op. cit.*, p. 252.

⁹ An excellent bibliography is provided in G. Neuenschwander, *Morphometrische Begriffe*, "Arbeiten aus dem Geographischen Institut der Universität Zürich," Serie A., No. 2, Zürich, 1944.

¹⁰ Note, for example, the lists of properties assembled in A. N. Strahler, "Dimensional Analysis Applied to Fluvially Eroded Landforms," *Bulletin of the Geological Society of America*, LXIX (March, 1958), pp. 279-300.

ments.¹¹ Under each of these heads might be compiled long lists of properties or indices, comparable to many items that might appear under the broad headings of temperature or precipitation in an analysis of climate. Some properties, such as inclination and dimensions, are readily handled in numerical form; others, most notably arrangements (such as patterns and profiles), are less readily quantifiable.

By resolving the land form into such components, a systematic and balanced description may be achieved, possessing the virtues of precision and comparability, free from the uncertainties of genetic interpretation, and stated in a form well fitted to the study of relationships with other phenomena of geographic interest.

The notion that the genetic approach is inherently capable of presenting a clearer picture with fewer words is an article of faith that does not bear scrutiny. The image conveyed by an explanatory description is no more detailed, full or precise than the explanation is detailed, full or precise. Genetic terms such as "marginal moraine," "naturally dissected plateau," or "cirque and glacial trough" are generalized and weak in genetic content. Any impression there may be of more specific implied descriptive detail arises from the filling in, by the reader, of the image of an example with which he is personally familiar, but which may be quite unlike the example being described. If an explanatory description is to be precise and detailed, then it must include those details and that precise measure of development that have produced the specific existing qualitative and quantitative attributes of the landscape. This, it is submitted, cannot be done concisely, either by genetic or empirical description. If conciseness is desired, it can be achieved only by generalization, using the usual techniques of limiting the number of kinds of information given, grouping data into larger classes, using various types of summaries, employing numerical expression where feasible, and by letting pictures, diagrams and maps do the work of many words. These techniques are, if anything, more readily adaptable to empirical than to explanatory description.

The picture, sometimes presented, of empirical description as "an endless and easily forgotten repetition"¹² is a straw man. There is no more need for endless cataloguing of features in empirical description than in genetic. The techniques of generalization just mentioned, the summarizing of the repetitive occurrence of characteristics over broad areas, the various illustrative techniques, and verbal virtuosity are all available to the employer of empirical method. In the hands of a careful, ingenious and gifted expositor there is no reason why an empirical description cannot be rendered highly palatable.

Kesseli has pointed out a definite problem that the user of empirical description does face, namely the lack of an adequate empirical terminology, partly the result of the turning of originally empirical terms to genetic purposes by geomorphologists.¹³ This is obviously remediable, though the coinage of new terms needs be approached with care and a sense of pro-

¹¹ E. H. Hammond, *Procedures in the Descriptive Analysis of Terrain*, Final Report, Office of Naval Research, Geography Branch, Project No. NR 387-015, Contract No. Nonr-1202 (01) (Madison, Wisc., 1958), pp. 5-57.

¹² Bryan, *op. cit.*, p. 204.

¹³ Kesseli, *op. cit.*, pp. 5 and 9.

portion lest a deluge of jargon be the result.¹⁴ Perhaps it is not yet too late to repossess some of the honest descriptive words upon which explanatory limitations have been placed. It would be well to add here a note of warning against regarding genetic terms as inherently dirty words. There is neither virtue nor common sense in avoiding the use of a genetic term for a feature of which the general origin is clearly established. It is only necessary to warn against assuming that these generalized genetic terms convey much of descriptive value.

In the last analysis, the test of any description is whether it has adequately served its purpose. It does not seem to be an obvious truism that the purpose of a description is to describe, while the purpose of an explanation is to explain. An explanation can serve as a description only if the origins of all the significant characteristics of the landscape are *known* and *specified* in the explanation. In the present state of knowledge of geomorphic processes and of past developmental environments this is simply not possible. But if that is true, then an "explanatory description" is not only, as Kesseli has termed it, "an explanation lacking a description,"¹⁵ it is not even, for geographical purposes, likely to be more than a tentative and incomplete explanation. For many purposes, functional and explanatory, students with a geographical point of view need to know the empirical facts about the land form of areas. Let these then be set forth in the most effective manner possible, free from the uncertainty and irrelevancy of genetic interpretation. If the study is one of genesis of existing form, then let the existing form be factually portrayed at the outset, permitting that portion of interest that is derivable only from explanation, to lure the reader on to the following interpretative section wherein his curiosity may be in part appeased. though never, in geomorphology, wholly assuaged.

¹⁴ An admirable example of an important move in the direction of empirical description, but a frightening example of the results of untrammelled coinage of terms is provided by U.S. Department of Agriculture, Soil Conservation Service, Soil Survey Staff, *Soil Classification, A Comprehensive System, Seventh Approximation* (Washington: Government Printing Office, 1960).

¹⁵ Kesseli, *op. cit.*, p. 5.

A COASTAL RECONNAISSANCE OF CENTRAL PANAMA*

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This paper represents an attempt to give an explanatory account of the coastal features of central Panama. It is based on field observations in the summer of 1959 and on the study of all pertinent literature available to the writer in Panama and in the libraries of the University of California and the University of New Mexico. Field work was facilitated by: (1) The availability of topographic maps made by the Panama Canal Company and the Corps of Engineers of the U.S. Army (For certain coastal areas, these maps are drawn on a scale of 1:20,000 with a contour interval of twenty feet), and (2) the accessibility of the coasts. The Pacific coast can be reached by jeep for wide stretches from Panama City westward to David. The Atlantic coast is more difficult to approach from the land. In 1959 one could drive from María Chiquita to Salud, and to several fishing villages between these two points.

DESCRIPTION

Atlantic Coast; Canal Zone and East (Figures 1 and 2). The Atlantic side of the Canal Zone displays two major types of coast: broad bays fringed by swamp deposits known as muck, and silt islands that have accumulated on reefs of dead coral. The two largest bays, Limón and Manzanilla, are separated by a silt island on which Colón is built. Limón Bay has a smooth and rounded outline. The depth of its floor increases from five feet near the southern shore to 40 feet at the mouth. Strong and persistent trade winds used to produce heavy swells that did much damage to the wharves and shipping in the bay prior to the construction of breakers. The outline of the bay is at least partly the result of wave erosion, for Hill¹ described how the high swash of the waves constantly undermined the bay's muck-lined shore.

Muck or littoral swamp deposit is widely distributed along both the Atlantic and Pacific coasts of Panama². On the Atlantic side it is exposed around the edges of Limón, Manzanilla and Las Minas bays, and in the lower Chagres valley. The thickness of the deposits varies greatly and this large variation suggests that the muck covers an uneven bedrock floor. For example, at Limón Bay the thickness of muck is 83 feet³; at the mouth of

* The field work for this paper was carried out under ONR Contract 222 (11) NR 388 067, University of California, Berkeley. Many people have helped me in various ways. In particular I wish to acknowledge my indebtedness to Professors James J. Parsons, B. L. Gordon, and Homer Aschmann; to Miss Evelyn Pruitt, Messrs. R. A. Terry, Thomas Moy, and Martin Burkenroad; and to my father, Dr. M. L. Tuan. The method of approach and manner of presentation reflect the influence of Professor John E. Kesseli. The errors, however, are my own.

¹ R. T. Hill, "The Geological History of the Isthmus of Panama and Portions of Costa Rica," *Mus. Comp. Zoology*, Vol. 28, 1898, p. 174.

² *Ibid.*, pp. 173, 199; *Report of the Governor of Panama Canal, 1947*, Public Law 280, 79th Congress, 1st Session, Appendix 8: "Geology, Isthmian Canal Studies" (hereafter cited as *Report of Governor*), pp. 9-10.

³ D. F. MacDonald, "The Sedimentary Formation of the Panama Canal Zone with Special Reference to the Stratigraphic Relations of the Fossiliferous Beds," *U. S. Nat. Mus., Bulletin* 103, 1919, p. 13.

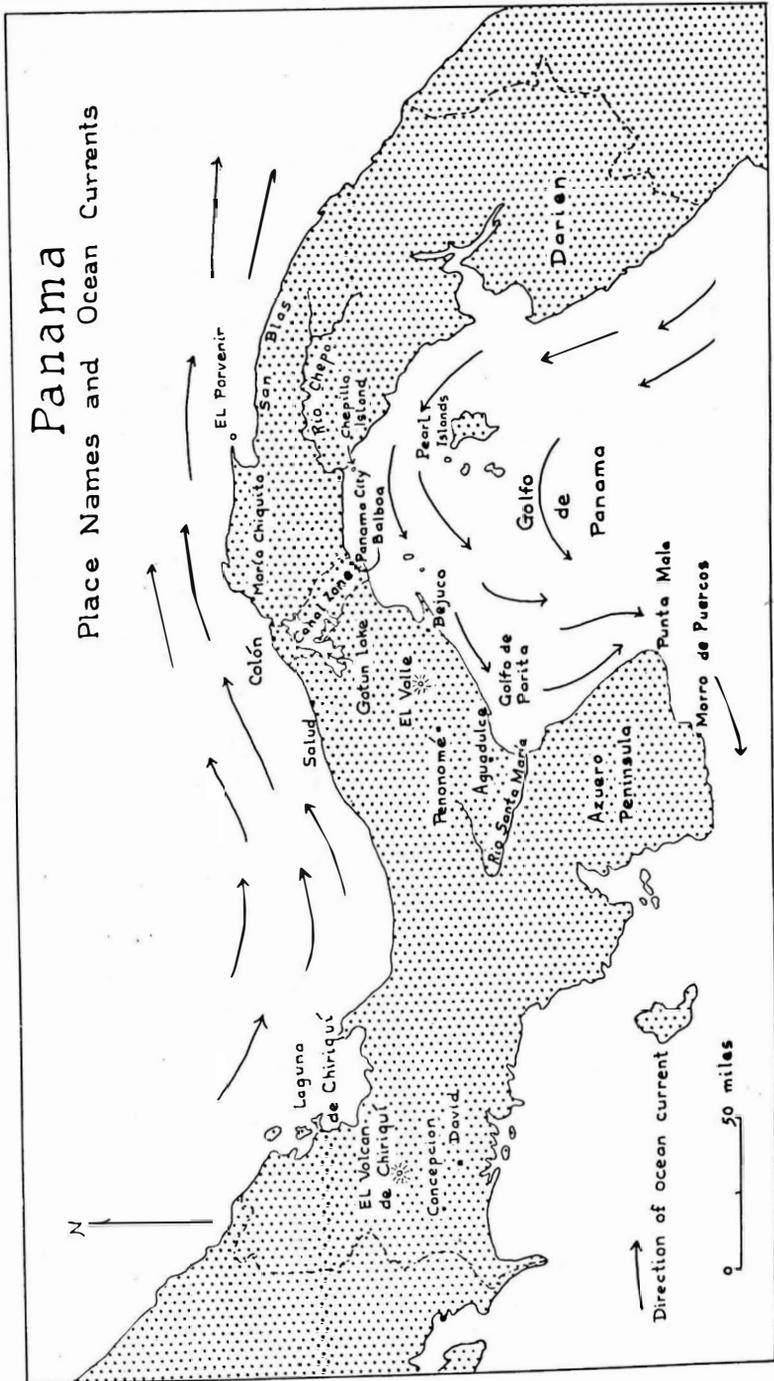


Fig. 1. Place names and ocean currents, Panama.

the Río Chagres it is 50 to 60 feet⁴; at Gatun Dam, 258, feet⁵; at Bohio, 150 feet⁵, and at San Pablo, 90 feet⁵.

Muck consists of soft, silt-sized sediments. Near the coast both marine and fluvial facies occur, and they intergrade laterally. Marine sediments include an abundance of mollusk shells, believed to be of Pleistocene to Recent age, in an organic black silt matrix.⁶ Fluvial sediments include wood and other semi-decayed vegetable matter intermixed with silt. The shell-bearing muck now appears five to ten feet above sea level.

Colón is built on a small square piece of land, which originally was a mangrove swamp, later filled from the work of the railway and canal. Northeast of Colón, Galeta and Largo Remo Islands are still mangrove

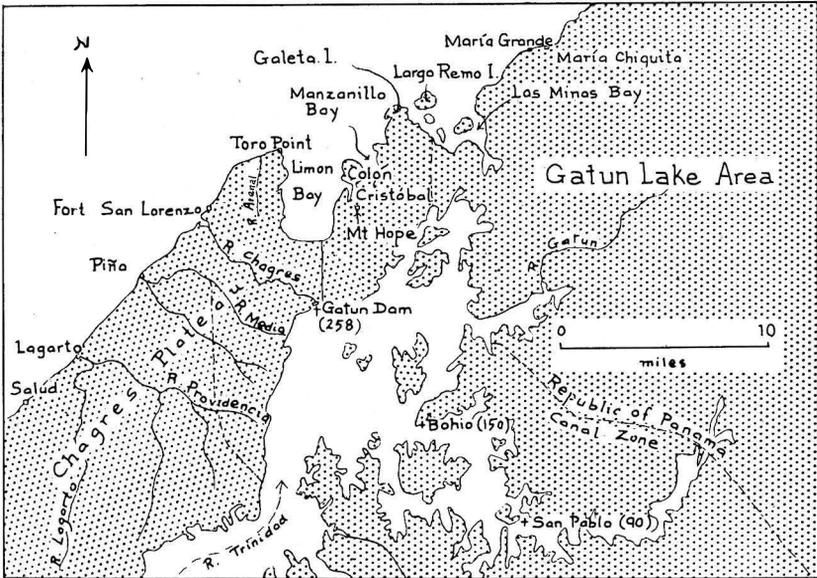


Fig. 2. Gatun Lake Area.

swamps behind their fringing reefs (Figure 3). The surface of the reef flat is convex seaward in outline and disappears where streams enter the sea. It lies one to two feet below sea level for a distance of 300 to 1,000 feet. Blocks of cemented coral, detached and thrown up by storm waves, litter its surface and project above water. The flat of dead corals continues seaward to a depth of about 12 feet where the edge then descends more steeply to 30 or 40 feet within a horizontal distance of 1,000 feet. East of Las Minas Bay the distance between fringing reef and mainland bedrock narrows so that about one mile east of María Grande, the fringing reef disappears and a smooth beach backed by a wave-cut clifflet two to five feet high faces the open sea.

⁴ L. W. Bates, *The Panama Canal: System and Projects*, 1905, pp. 22-23.

⁵ F. D. Willson, "The Climatology and Hydrology of the Panama Canal," Paper no. 9, in: *The Panama Canal*, Vol. 1, 1916, pp. 273-274.

⁶ *Report of the Governor*, p. 22. W. P. Woodring, "Geology and Paleontology of Canal Zone and Adjoining Parts of Panama," U. S. Geol. Survey, *Professional Paper* 306-A, 1957, p. 50.

Between Limón and Las Minas Bays, the bedrock of sandstone, siltstone and tuff has been eroded into hills and clusters of hills surrounded by muck. These prominences reach 40 to 60 feet in elevation near the coast. R. T. Hill⁷ noticed the accordance at 40 feet of the summits of Monkey Hills south of Mt. Hope. Inland, the rugged hilly topography does not clearly reveal any erosional surface. However, east of the Canal Zone,

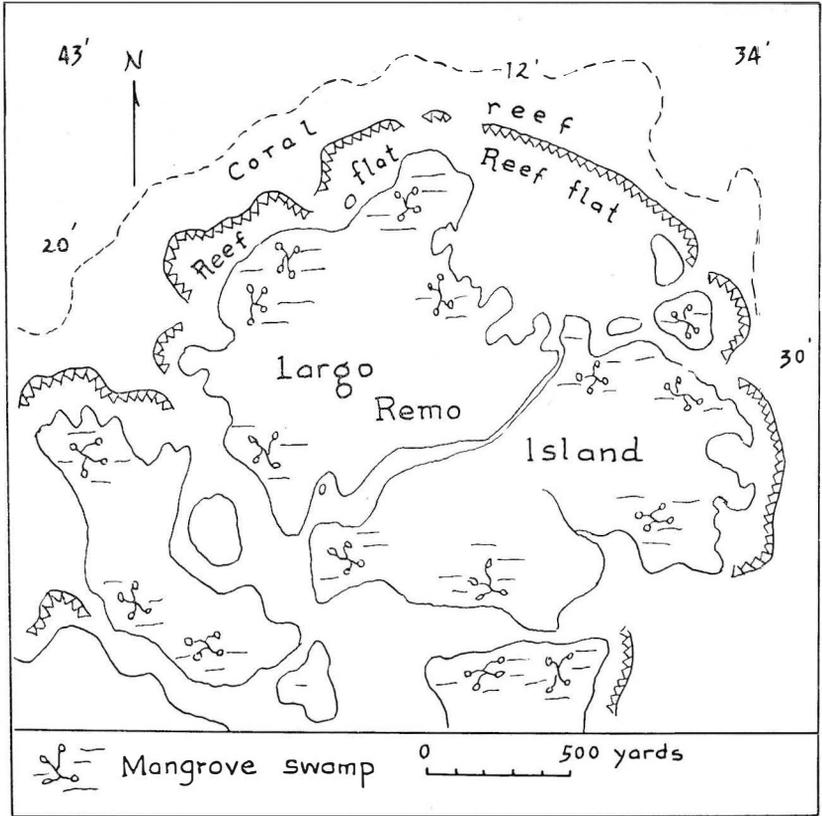


Fig. 3. Largo Remo Island. Mud and silt have collected on dead coral flats. (See Figure 2 for location).

Terry observed small terraces notched in igneous rocks. They are seldom more than a mile or two in width and are interrupted by fingers of the interior plateau extending to the sea⁸.

Atlantic Coast; Canal Zone and West. A deeply dissected plateau lies to the west of Limón Bay. It is formed in a massive sandstone that dips seaward at angles of 5° to 15°.⁹ Most of its surface lies below 350 feet though its summits may rise above 600 feet. Streams that originate at its

⁷ Hill, *op. cit.*, p. 174.

⁸ R. A. Terry, *A Geological Reconnaissance of Panama* (San Francisco: Calif. Academy of Sciences, 1956), pp. 16-17.

⁹ MacDonald, *op. cit.*

southeastern edge, such as the Providencia, Media and Piña, occupy broad, alluviated valleys in their headwaters. Near the coast, however, they are deeply entrenched. Río Chagres also reaches the sea through a deep valley cut into the plateau. But above Gatun Dam, Río Chagres and its tributaries used to move sluggishly across broad swamps before these were

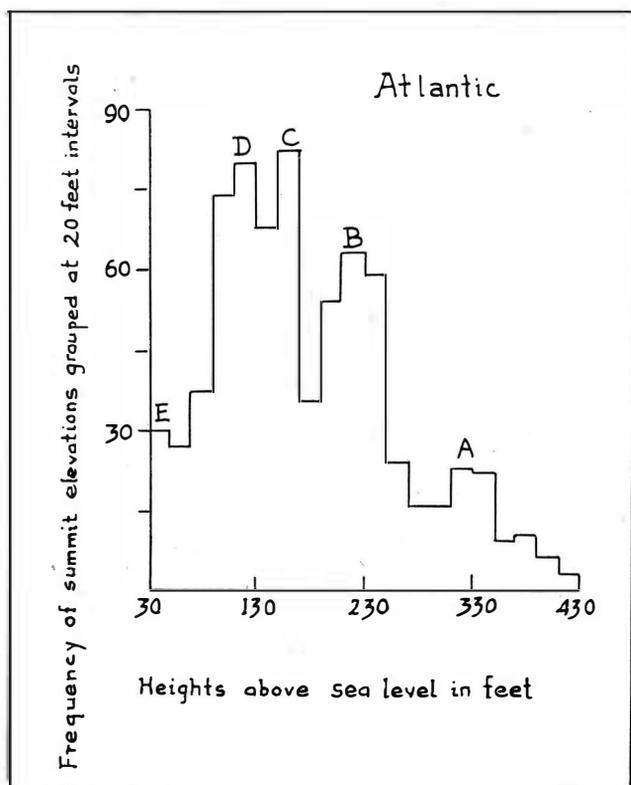


Fig. 4. Altimetric frequency graph for the Atlantic coast. The graph is drawn for an area of 15 square miles in the neighborhood of Pina, Chagres plateau. The area is divided into a rectangular grid and the summit elevation for each square of the grid is read from the topographic map made by the Panama Canal Company and the Corps of Engineers, U. S. Army. The scale of the map is 1:20,000 and the contour interval is at 20 feet. The frequency of each group of summit elevations (e.g., 30 to 50 feet) is plotted on the vertical scale against actual heights on the horizontal scale.

flooded into the artificial Gatun Lake (Figure 2). The drainage pattern and topography thus suggest that the sandstone plateau has been uplifted in relation to the basin now submerged in water. Geologically recent fault scarps, 50 to 150 feet high and draped by waterfalls, bound the southeastern landward edge of the sandstone plateau.¹⁰ The rise of the plateau relative to the sea is marked by benches. The altimetric frequency graph suggests the existence of at least five of them (Figure 4): A, 310-350 feet; B, 210-230 feet; C, 150-170 feet; D, 100-120 feet; E, 40-50 feet.

¹⁰ S. M. Jones, "Geology of Gatun Lake and Vicinity," *Bull., Geol. Soc. America*, Vol. 61, 1950, p. 906.

Although the lowest bench (E) is the least conspicuous on the graph, it can be discerned most readily in the field for it is in places cleared of vegetation.

For a distance of nearly four miles from Toro Point west of Limón Bay, a reef of dead coral fringes the steep coast. Farther west the reef disappears, and the coast, 25 to 30 feet high, is bordered locally by a

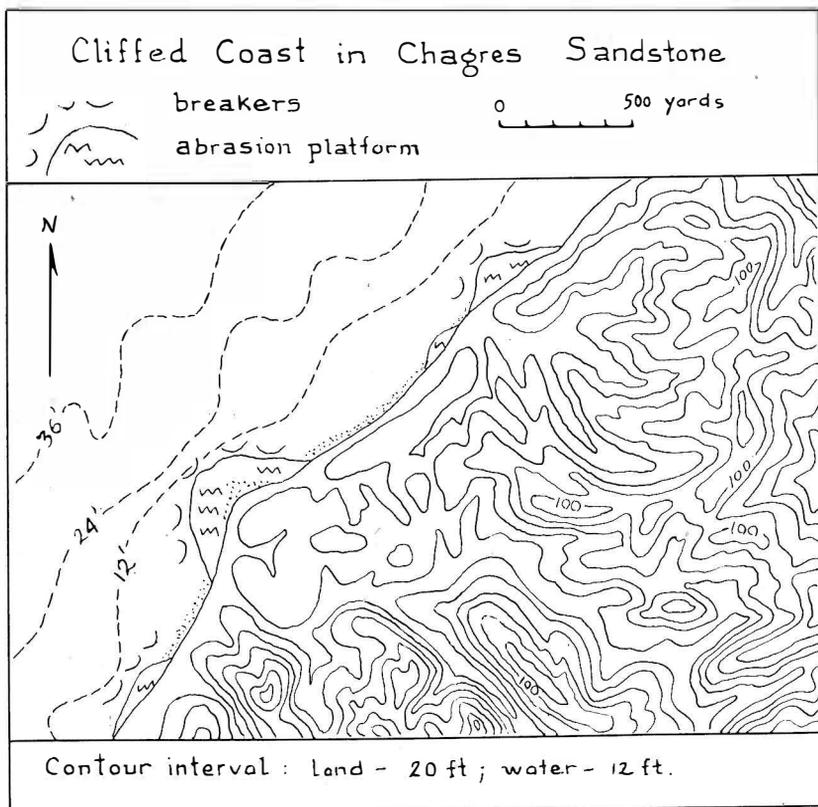


Fig. 5. Cliffed coast in Chagres sandstone, and showing stranded abrasion platforms. Topography after U. S. Corps of Engineers.

smooth platform cut by waves in the massive sandstone. The platform is awash and its edge is marked by breakers (Figure 5). This exposure is not limited to low tide for the tidal range is negligible, being less than one foot. Where it occurs, the platform fringes the seaward protrusions of the coast even where the protrusion is very slight. In contrast, each coastal indentation is lined with beach sand. In some places, a low, weathered bench, covered with vegetation, stands one to three feet above the modern beach. The inner edge of this bench rises to the higher one of 40 to 60 feet elevation (Figure 6).

Apart from the narrow strips of beach sand, most of which have been cliffed by wave erosion, depositional forms are uncommon along the coast from the Río Arenal westward to the mouth of the Río Lagarto. The

mouth of the Río Chagres is narrowed by the extension northeastward of a spit. The outer flank of this spit, however, is retreating rapidly under wave attack. Smaller spits, variously oriented, occur in entrants between promontories.

Pacific Coast; Canal and East (Figure 7). Panama City and adjoining Balboa in the Canal Zone lie on top of a coastal bench eroded in

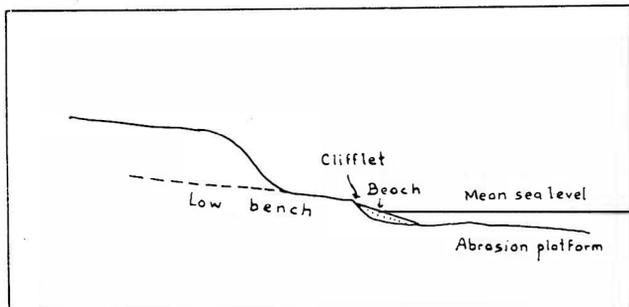


Fig. 6. Low, weathered bench.

tuff and agglomerate. The altimetric frequency graph for this area shows the prevalence of height readings between 10 and 50 feet (Figure 8). The 20-foot interval of the graph fails, however, to distinguish between the low coastal swamps, which lie below 15 feet, and the bedrock surface at 30 to 60 feet.

In sharp contrast to the graph for Chagres plateau, the graph for the Pacific bench shows only one prominent maximum—a frequency distribution that characterizes a simple coastal plain. Small benches may well

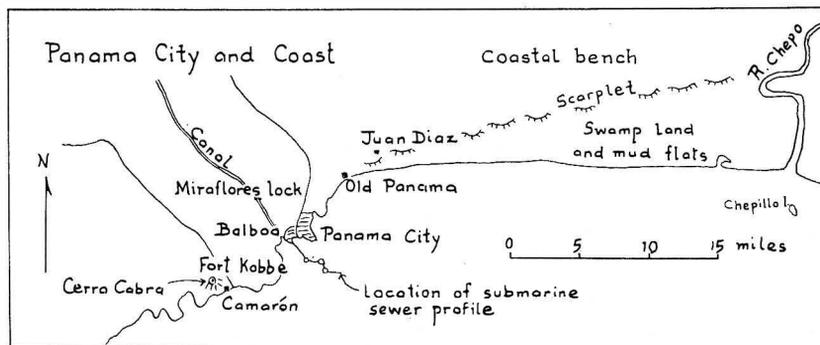


Fig. 7. Panama City and coast.

have been omitted by the crudity of the method, but the same method was applied to the Chagres plateau. This morphologic difference between the two sides of the isthmus is obvious in the field, and the graphs serve simply as a check on field observations.

The outer edge of the coastal bench is a scarplet that varies in height from five to 20 feet. Seaward it is fringed by broad expanses of mud and bedrock flats that are exposed at low tide. Muck similar to that described for the Atlantic coast occurs to depths of 40 feet or more from Miraflores

Lock to the Pacific entrance of the canal and beyond.¹¹ Marine fossils have not been reported in the muck at Miraflores Lock, where the original bottomland was over 10 feet above the present mean sea level. On the other hand, the lower swamps that formerly bordered Balboa and Panama City on the landward side do contain shells.¹²

East of the ruins of Old Panama, rocks of the bench change from volcanic tuffs and agglomerate to sandstone and siltstone. The flat parts

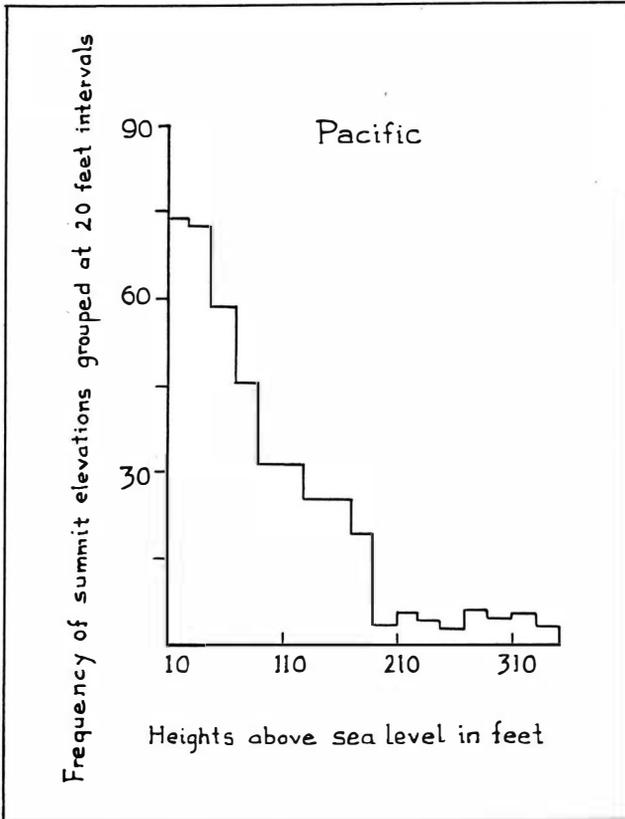


Fig. 8. Altimetric frequency graph for coastal bench north of Panama City. The graph is drawn for an area of 15 miles. (See Figure 4).

of the bench's gently rolling surface bear thin patches of alluvium and lie above the streams, many of which occupy valleys some 50 to 80 feet deep. Weathered bedrock occurs in shallow road cuts. The outer edge of the bench is a scarplet almost 15 feet high, fringed by a swampy grass land. Toward the sea, mangroves (e.g., *Avicennia* spp.) appear. Sand ridges rise above both the grass and mangrove swamps. At the longitude of Juan Diaz, the mangrove belt is narrow and bordered by eroded mud flats. Cakes of

¹¹ Report of Governor, p. 10.

¹² G. A. Maack, in: T. O. Selfridge, *Reports of Explorations and Surveys to Ascertain the Practicability of a Ship Canal between the Atlantic and Pacific Oceans by Way of the Isthmus of Darien* (Washington, D. C., 1874), p. 165.

old mud, still supporting dying mangrove, stand sharply above a younger mud flat that is exposed for one mile offshore during low tide. The entire zone of swamps, sand ridges, and mud flats increase in width eastward to Darien Province. West of old Panama, the trend of the coast line corresponds to the outer edge of the bedrock bench. East of there it corresponds to soft material of the coastal swamps.

Pacific Coast; Canal Zone and West. In Fort Kobbe west of the Panama Canal, a bench cut in volcanic rocks fringes steep-sided knolls (Figure 9). Near Howard Field, it borders an inlet of mangrove swamp drained

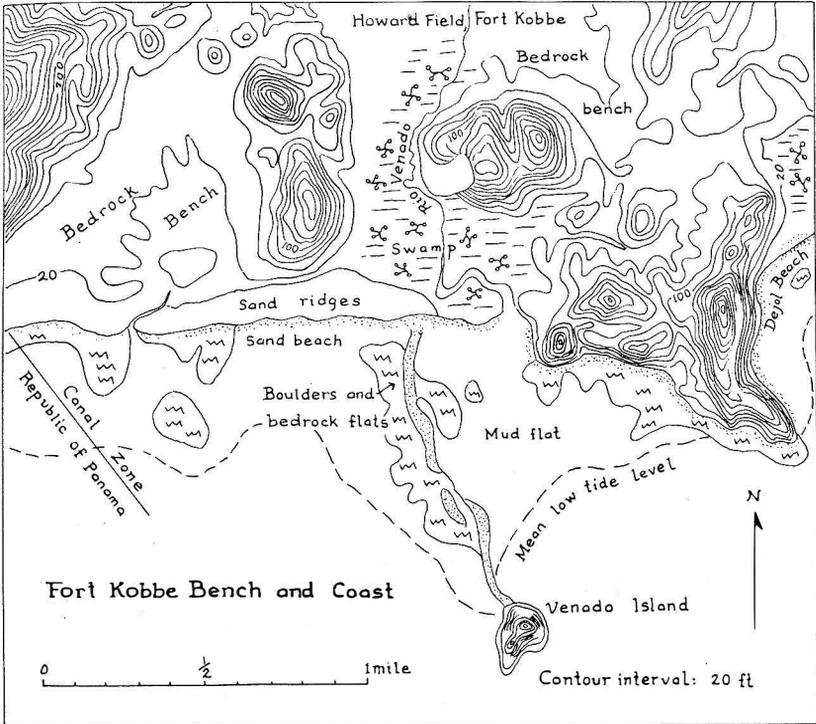


Fig. 9. Fort Kobbe, bench and coast.

by the Río Venando. The seaward edge of the swamp ends in a sand ridge, beyond which spread mud flat, patches of bedrock boulders and bedrock. At Dejal Beach, Fort Kobbe, the sand beach is fringed seaward by a clifflet cut in bedrock that marks the outer edge of a low weathered bench. The inner edge of this low bench rises to the higher one on which Fort Kobbe is located.

West of the Canal Zone boundary, the coastal plain at the foot of the Cerro Cabra (1,980 feet) is less than a quarter of a mile wide, and composed of volcanic bedrock thinly veiled by alluvium. It terminates in beach sand, beyond and below which lies bedrock of the marine abrasion platform. Stands of mangrove find a precarious foothold in the silt that accumulates in the hollows of the platform. During high and mean sea level, surf

waves move across the platform and through the trees to the sand beach (Figure 11). The mangrove stands appear to be in process of destruction.

Between Bejuco and Penonomé are massive beds of water-sorted tuff, thin layers of fine alluvium and beds of mud-flow conglomerate with boulders that may be two or three feet in diameter. The formation, deposited around the El Valle crater, is believed to be of Middle Pleistocene age.¹³ Streams radiate outward from the crater. They cut deep canyons and leave behind flattish interfluves. Although the drainage pattern is radial, the cliffed coast line from Pueblo Nuevo to Nuevo Gorgona is nearly

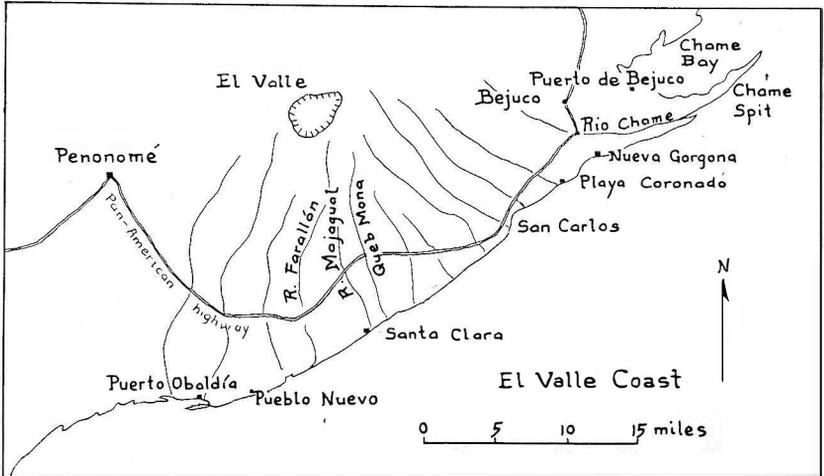


Fig. 10. El Valle coast.

straight (Figure 10). Waves appear to have straightened it and produced the cliffs. The eroded material is carried both northeastward and southwestward by longshore drift. This disposition of material is indicated by the deflection of the lower stream courses. In the northeastern part of the coast, Río Chame is deflected northeastward by a forested sand spit for a distance of six miles. Beyond the mouth of Río Chame is the Chame sand spit, which continues seaward for seven miles. The spit partially encloses a body of water, Chame Bay, over which mud flats have developed. In the southwestern part of this coast, the lower stream courses are deflected southwestward by sand spits. The lower course of Río Farallón is an example. Between these extremities of the tuffaceous coast, no distinct trend of longshore and beach drifting occurs. East of Santa Clara, for instance, the Río Majagual is deflected northeastward, whereas the Queb Mona to the northeast is deflected southeastward. The streams thus run into each other, and both hug the base of the tuffaceous cliff.

PRESENT PROCESSES

Effect of Currents. On the Atlantic side, the offshore current moves from west to east; in the northern part of the Golfo de Panama of the Pacific, it moves from east to west (Figure 1). Both currents are weak,

¹³ O. H. Hershey, "Geology of Central Portion of Isthmus of Panama," *Univ. Calif. Bull., Dept. Geol.*, Vol. 2, 1901, p. 260; Terry, *op. cit.*, p. 15.

their average velocity being less than one knot.¹⁴ Offshore currents can have no direct effect on coastal features but indirectly their load of suspended matter may contribute to the building of mud flats when it is carried in by flood tide. On the Pacific side, stray logs from the timber mills of Darien Province have been carried northwestward for over 70 miles, and dropped on the mud flat east of Río Chepo with the retreat of high spring tide.¹⁵ East of the canal entrance a causeway was built to Naos Island to deflect the westward movement of currents carrying mud, and so reduce the cost of dredging the channel. The mud was estimated to amount to over one-half million cubic yards per year.¹⁶

Effects of Tides. Tides differ greatly along the two coasts.¹⁷ At the Atlantic entrance to the Panama Canal the tide has an average rise and fall of 0.9 foot, with a maximum of two feet between successive high and low tides, and generally there is but one high and one low tide in a day. At the Pacific entrance to the canal there are two high and low waters during the day, the average rise and fall being 12.6 feet and at times over 20 feet.

Observers like Hantzschel,¹⁸ Boucart and Francis-Boeuf,¹⁹ and van Straaten,²⁰ based on experiences in Europe, evoke the tide as an agent in the building of mud flats. Evidence in Panama supports this view, for wide mud flats fringe only the Pacific coast of high tidal range. Mud from streams and offshore currents are carried in by flood tides and deposited near shore during the slack periods as the tide turns. The source of mud along the Pacific coast appears to be largely local, for both the Aguadulce and the Juan Diaz mud flats border low erosional plains drained by sluggish rivers, the Río Santa María in the former, and the larger Río Chepo in the latter. The mud continues for three or four miles beyond the main shore line. Opposite the mouth of Río Chepo, the depth of water four miles offshore (to Chepillo Island) is about 10 feet. Opposite the mouth of the smaller Río Santa María, shallow water with a mean depth of about 10 feet occurs three miles offshore. The water in both areas then deepens to 30 or 40 feet within a mile. This slope may correspond to the edge of mud supplied by the rivers.

Effect of Wave Action. The force exerted by waves on the coast depends on their size, which varies with the velocity of the winds, their fetch, and on the width and depth of the continental shelf. The length of the fetch is greater on the Atlantic than on the Pacific side, for the nearest island of the Caribbean Antilles, Jamaica, is almost 600 miles from the

¹⁴ *Pilot Charts of the Central American Waters*, 2nd edition (Washington, D. C.: Hydrographic Office, 1955).

¹⁵ R. A. Terry, personal communication.

¹⁶ H. H. Rousseau, "Terminal Works, Dry Docks and Wharves of the Panama Canal," *The Panama Canal*, Vol. 2, 1916, Paper No. 23, p. 418.

¹⁷ Willson, *op. cit.*, pp. 263-264. H. A. Marmer, "The Tides at the Entrance to Panama Canal," *Geog. Rev.*, Vol. 16, 1926, pp. 502-503.

¹⁸ W. Hantzschel, "Tidal Flat Deposits," in: P. D. Trask, *Recent Marine Sediments: A Symposium* (London: Thos. Murby & Co., 1939), p. 202.

¹⁹ L. Boucart and C. Francis-Boeuf, *La Vase* (Hermann & Co., 1942), p. 42.

²⁰ L. M. J. U. Van Straaten, "Texture and Genesis of Dutch Wadden Sediments," *Proc. Third Int. Congress of Sedimentation* (Groningen-Wageningen, Netherlands: 1951), pp. 239-240.

Atlantic coast, whereas the Golfo de Panama opens out to the west coast of Colombia and the two shores are about 250 miles apart. Moreover, Pearl Islands in the Golfo de Panama are only 25 miles from the Panamanian coast. The prevailing winds are onshore and from the northeast on the Atlantic side; they are offshore, from the north and northwest on the Pacific side.²¹ In the dry season between January and April, the trade winds sweep across the entire isthmus. This is the season of strongest onshore winds along the Atlantic coast. The average velocity of 15 knots is frequently exceeded. Average wind velocity is also greater during this dry season along the Pacific coast but the winds are offshore. During the wet season, between May and December, the winds are weaker and more variable. Though prevailing winds are still from the north along both the Atlantic and the Pacific coasts for the wet season as a whole, in September and October they are from the southwest in the Golfo de Panama. The continental shelf is from five to 10 miles wide on the Atlantic side, and its shoulder occurs at a depth of 300 feet. On the Pacific side, the shelf underlies the Golfo de Panama and the 300-foot depth contour is 45 miles from the coast. From these considerations and from direct observation of size, waves appear to exert a greater force on the Atlantic than on the Pacific coast.

Beach drifting, the deflection of stream courses, and the building of spits result from wave action. The coast of El Valle illustrates this process. The conical curvature of El Valle is indicated by the radial pattern of its streams. However, wave erosion has straightened and cliffed the curved base of the cone. The cliffed coast is oriented approximately at right angles to the direction of maximum fetch from which the dominant winds and largest waves may be expected to come. Wave action is thus not related to the prevailing winds, which are offshore for the Pacific coast. The material eroded from the cliff and brought down by streams from the flank is carried in opposite directions through beach drifting, northeastward to Chame spit, and less conspicuously, southwestward to a spit opposite Puerto Obaldía. By far the greater portion of the material moves northeastward, and the dominance of this drift is probably related to the fact that the strongest winds, up to 38 miles per hour, are from the south and southwest in September and October.

Turbulent water generated by large waves hinders the deposition of mud. Along the Pacific shore, broad mud flats occur in the sheltered Golfo de Parita opposite the Aguadulce Plain and in Chame Bay behind Chame spit. East of Juan Diaz, a low, irregular scarplet is bordered seaward by swamps, sand ridges and mud flats; and this depositional coast line has an east-west trend, oriented at right angles to the direction of maximum fetch. The low erosional plain behind the scarplet indicates that even before the deposition of mud, the offshore zone was probably shallow, and over this shallow expanse of water, waves from the direction of maximum fetch have prograded the shore line.

Between the Atlantic and the Pacific coasts, the gradient of the immediate offshore zone differs appreciably, as the coastal profiles (Figure 11) and the following table show.

²¹ F. W. Pope, *A Study of Weather Conditions in Panama with Special Emphasis on the Belt of Doldrums* (Canal Zone: Albrook Air Base); *Pilot Chart of Central America Waters*, 1955.

Depths of Water One Mile from Mean Shore Line

Atlantic	1. Low coasts	30-45 feet
	2. Cliffed coasts	55-65 feet
Pacific (Golfo de Panama)	1. Mud-flat coasts	less than 10 feet
	2. Low coast	15 feet
	3. Cliffed coasts	25 feet

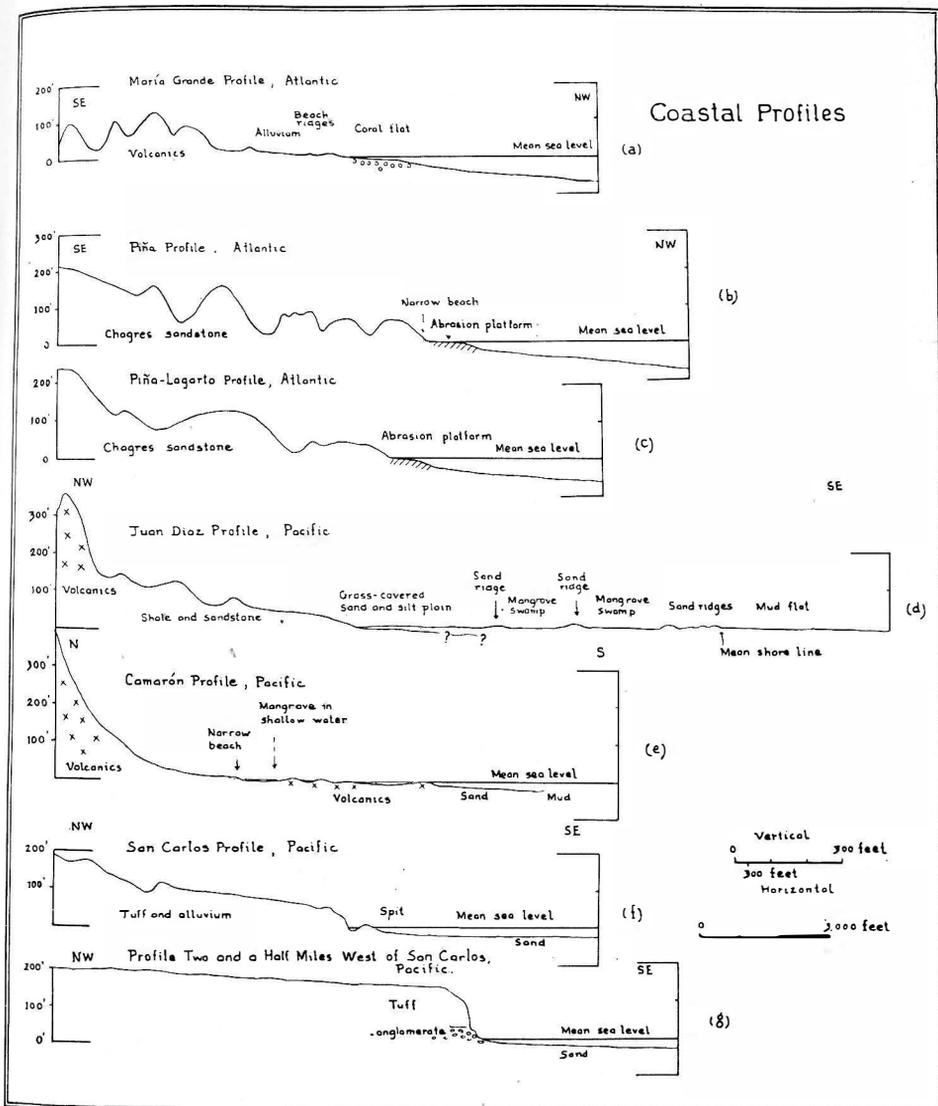


Fig. 11. Coastal profiles of central Panama.

Difference in the size of waves may be a factor in the contrast between Atlantic and Pacific depths within one mile offshore. On the Pacific side, low coasts bordered by swamps and mud flats have shallow, offshore water. On the Atlantic side, east of Limón Bay, low coasts bordered by swamps may descend to depths of 30 feet within 1,000 feet of horizontal distance. Explanation lies in the fact that the mud and silt of the low Atlantic coast have collected behind a fringing coral reef, and the steep slope offshore is the slope of the reef, not that of the mud. Where fringing reef does not occur, as on either side of Colón, waves propelled by strong onshore winds have enlarged bays. Though submergence may have initiated Limón Bay, its present size and shape is the work of waves. Fringing reef does not appear along the Pacific coast either, but here the evidence is of over-all progradation and an extension of the coast line seaward.

Cliffed coasts also show significant contrast in the depth of offshore water. Here again the greater depth of the Atlantic side may be due to its exposure to larger storm waves.

Effect of Sea-Surface Temperature. The surface temperature of sea water on the two sides of the isthmus differs significantly.²² From January through April, it is 80 to 82°F on the Atlantic, and 72 to 74°F on the Pacific side. Strong upwelling occurs in the Golfo de Panama regularly each year during this season, for this is the time when northerly winds are blowing offshore and the warm water at the surface is replaced by colder water from below. From May to December, the difference in sea surface temperature between Balboa on the Pacific side and Cristobal on the Atlantic side is small; both stations record temperatures of 80 to 82°F, with the Atlantic station usually showing a higher register by 1°F.

Fringing reefs are common in the warm winters of the Atlantic coast, especially in the Golfo de San Blas, where reefs and islands of coral sand dominate the seascape. West of San Blas, an interrupted fringing reef borders both low and steep coasts. The cool Pacific waters in the months between January and April apparently suffice to prevent the development of coral reefs nearshore. The greater deposits of mud along the Pacific coast and the fresh water at the mouths of the larger rivers may be additional factors. However, even where the mud flat is absent, as along the coast of El Valle, reef corals do not grow.

LAND AND EUSTATIC MOVEMENTS

To sketch the history of coastal land forms in Panama, one has to consider movements of both land and sea. Though topographic evidence for the occurrence of *relative* movements is usually clear, whether the dominant motion was by land or by sea can be inferred with much less certainty.

Evidence for Relative Movement. (1) Benches. On the Atlantic side, at least five benches occur on the Chagres Plateau. They also appear east of the canal Zone. On the Pacific side, only one, the present coastal plain, is clearly discernible. It continues westward to Bejuco but west of Chame it is hidden by an increasing thickness of tuffaceous alluvium and the bedrock is exposed only at the base of the sea cliff.

²² M. B. Schaefer, Y. M. M. Bishop, and G. V. Howard, "Some Aspects of Upwelling in the Gulf of Panama," *Inter-American Tropical Tuna Commission, Bull.*, Vol. 3, 1958, no. 2.

No marine deposits are known to exist on the benches. On the Atlantic side benches are deeply dissected and appear locally as the accordant summits of knolls, for example, Monkey Hills. Nevertheless waves probably cut the benches, excepting perhaps the highest one. This marine origin is suggested by the fact that they lie close together within a belt of only three miles from the coast. At present, the main rivers, being entrenched at their mouths, are not bordered by denudational surfaces whereas platforms of marine abrasion do fringe the sea cliffs. On the other hand, the highest plateau surface is probably of subaerial origin, for a gentle erosional topography still exists at the southeastern edge, where head-streams of the Providencia, Media and Piña occupy alluviated valleys. The Pacific coastal bench bears weathered alluvium, from coarse gravel to silt, on the interfluves. In contrast to the Atlantic benches, it appears to be primarily the work of subaerial processes. This suggestion, though based on inconclusive evidence, is in line with the operation of present processes, which show stronger marine erosion on the Atlantic than on the Pacific side. However, the steep outer edge of the Pacific bench is cut by waves. It rises as sea cliffs or as scarplets bordered by sand ridges and brackish-water swamps.

(2) Buried topography. Relative submergence of the land is abundantly attested by erosional topography buried by muck, or by muck and water. The artificial Gatun Lake itself occupies former swamplands of muck, the thickness of which varies from 90 to over 250 feet. The floor of the Pacific entrance of the Panama Canal consists of weathered bedrock overlain by muck as the borings taken in connection with a proposed bridge indicate.

A Sample of the Log for Balboa Bridge

Depth in feet	Description of Material ²³
0-14	<i>Muck</i> ; soft to medium soft, low plasticity, low dry strength, high water content, variably sandy and silty, very carbonaceous, abundant calcareous shell debris; color, dark blue-gray to black.
14-30	<i>Weathered bedrock</i> (dacite); medium hard to hard, moderate strength, closely jointed with joints highly weathered, fine grained, porphyritic; color, medium brown mottled with white.
30-115	<i>Sound bedrock</i> (dacite); very hard, strong, closely jointed, fine grained, porphyritic, containing many phenocrysts of white feldspar; color, light grey mottled with white.

Two and a-half miles from the present coast line, opposite the Pacific entrance of the canal, a submarine profile taken in connection with a proposed sewer shows a weathered, uneven bedrock surface covered by 10 to 30 feet of muck and sand and 15 to 50 feet of water (Figure 12). Sea level was therefore lower by at least 80 feet.

²³ R. H. Stewart, *Geological Logs of Drill Holes for Construction of Balboa Bridge Substructure, Canal Zone*, Panama Canal Company, 1959.

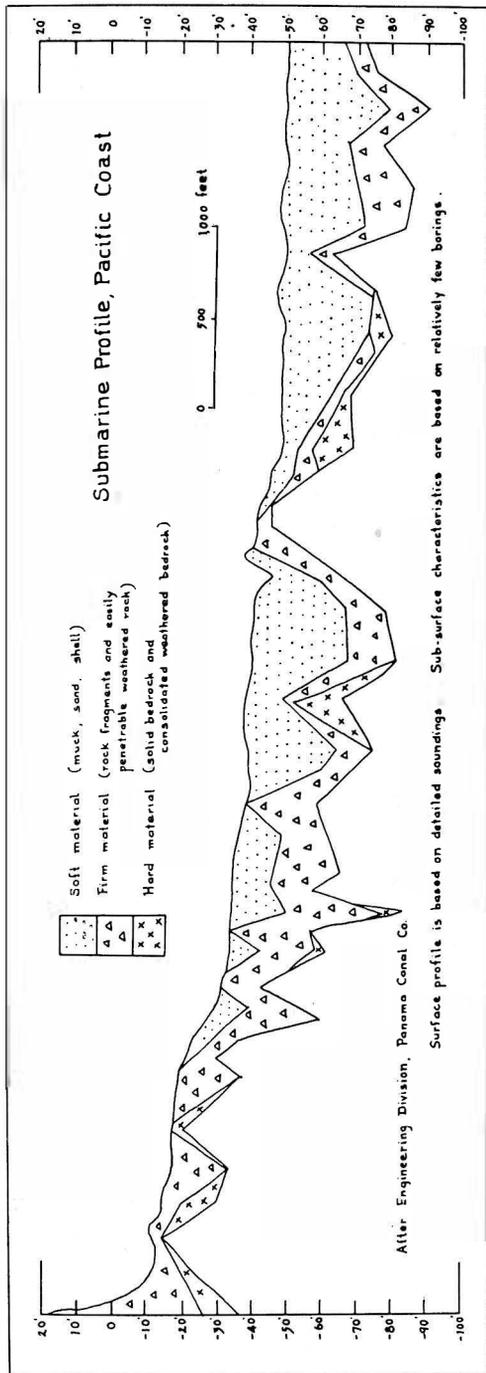


Fig. 12. Submarine profile, Pacific coast. (See Figure 7 for location.)

(3) Marine muck, dead coral flats, stranded platforms of marine abrasion, and low weathered benches. These features indicate a small negative movement of the sea. Exposed marine muck provides the clearest evidence for this movement. Dense clusters of dead corals flush with the sea surface also give strong support to the conclusion. Much less clear is the meaning of stranded platforms of marine abrasion, and of low, weathered benches.

A few stranded platforms, usually projecting beyond the tips of promunces along the coast, have been noted on the Atlantic side (Figure 5). Waves break at the outer edge of the platform and send a shallow swash over its surface to the base of the cliff. In the field, the sight of waves pounding on the outer edge of platforms has led me to believe that they will eventually eliminate it and produce a lower surface. Since the mean tidal range on the Atlantic side is less than one foot, it cannot alter significantly the level of concentrated wave attack and so nullify the pertinence of the observation. Along the Pacific coast the abrasion platform is continued seaward by a mud apron. In contrast, along the Atlantic coast the shallow water of less than 3 feet over the abrasion platform increases sharply to 20 feet beyond the platform's outer edge, where wave attack is taking place. The occurrence of stranded platforms supports the notion of a negative shift of sea level—a notion based on the independent evidence of marine muck and dead coral flats. By themselves, platforms are susceptible to another interpretation. Edwards, in his study of the coast of Victoria, Australia, suggests that the stranded platform is maintained by storm waves during high tide; only ordinary waves attack the platform's outer edge.²⁴ However, tidal range along the Atlantic coast of Panama seems too small to be an important factor, and it is difficult to see how storm waves could maintain rather than destroy the platform unless water level rises well above it.

In distinction to the marine platform, the low, weathered bench appears in sheltered embayments. The evidence of marine muck indicates a former sea level that would have covered the bench, but unlike the wave-cut platforms at the coastal protrusions the subsequent retreat of the sea has left the interior bench exposed to weathering. Not enough is known about the bench, its distribution and origin (whether it is cut by streams or by waves), for it to provide independent evidence of a small change in sea level, but its existence is a reasonable corollary of the hypothesis.

Evidence for Tectonic Movement. According to Jones, deformation appears to have been continuous in central Panama throughout Cenozoic time, for the older formation show progressively more disturbed conditions.²⁵ However, the youngest formation in the Gatun Lake area thus affected is the sandstone of Chagres plateau, which is probably late Miocene or early Pliocene in age.²⁶ Evidence for structural disturbance in the Quaternary period occurs in the form of fault scarps that Jones recognized at the southeastern edge of the Chagres plateau. These scarps rise at intervals as straight, undissected cliffs 50 to 150 feet above Gatun Lake.²⁷ At

²⁴ A. B. Edwards, "Wave Action in Shore Platform Formation," *Geological Magazine*, Vol. 88, 1951, pp. 41-49.

²⁵ Jones, *op. cit.*, p. 906.

²⁶ Woodring, *op. cit.*, p. 50.

²⁷ Jones, *op. cit.*, p. 908.

Gatun Dam the thickness of alluvium and muck is 258 feet. The bed-rock floor is therefore some 200 feet below present sea level. North of Gatun Dam, Río Chagres cuts across Chagres plateau to the sea through a valley 300 feet deep. Since the river must once have flowed on the plateau's surface, a differential movement of the order of 500 feet has taken place.

The Pleistocene eruption of El Valle attests to structural instability. Fault movements along its flanks have occurred in Recent time.²⁸

Evidence for Eustatic Movement. Sea level has oscillated with the expansion and contraction of ice sheets in the northern hemisphere during the Pleistocene period. Topographic evidence for such movements, such as a bench, is reliable only if it can be traced over wide stretches of the coast. Benches of Panama are fragmentary, and the writer has been able to trace them for only short distances on either side of the Canal Zone.

From available evidence, two movements, primarily of sea level, appear to have taken place. One is the rise of sea surface that resulted in widespread drowning of erosional topography, evident especially on the Pacific side, and the other is the slight drop in more recent time. That the drowning of erosional topography is due to the rise of the sea rather than to depression of the land is suggested by the rapidity of the movement; so rapid that weathered rock and regolith have not been removed from the submerged surface. This rise of sea level may have taken place from 8,000 to 12,000 years ago with the last major deglaciation. The mollusks found in the Atlantic muck are known to be living in the Caribbean Sea,²⁹ but no radio-carbon dating on them or on the carbonized wood is yet available.³⁰ The more recent withdrawal of the sea, perhaps of the order of 10 feet, is suggested by the testimony of several types of evidence. The occurrence of marine muck only a few feet above high tide level on both sides of the isthmus, around Limón Bay and north of Panama City, suggests a withdrawal of the sea. On the Atlantic coast are flats composed of dense clusters of dead corals. The fact that these coral flats, from the base of the Chagres plateau to Golfo de San Blas, all appear at one or two feet below the mean sea level suggests eustatic rather than land movement, for with land movement one might expect greater difference in their relative elevations. Live corals now grow sporadically at depths of three to five feet. Dense clusters need slightly greater depth. The appearance of dense clusters of dead corals at the present sea level suggests a retreat of the sea by at least 10 feet. The stranded abrasion platforms and the low benches agree with this conclusion.

HISTORICAL OUTLINE AND SUMMARY

From the survey of evidence for land and eustatic movements, the following sequence of events may have taken place in central Panama. The land rose relative to the sea. Benches, of which five are discernible on the

²⁸ Terry, *op. cit.*, p. 15.

²⁹ Woodring, *op. cit.*, p. 50.

³⁰ After the manuscript had gone to press, the author received the following C14 report from the United States Geological Survey through the courtesy of Dr. W. P. Woodring. The ages of three samples of muck, two from the Pacific side and one from the Caribbean side, are as follows:

Balboa Bridge core hole (BBR-53)—6,700 ± 300 years (Lab. No. W-958)

Balboa Bridge core hole (BBR-128)—7,680 ± 300 years (Lab. No. W-959)

Mindi Road Bridge core hole, Mindi 2—7,240 ± 300 years (Lab. No. W-960)

Chagres plateau and at least one on the Pacific side, have been cut. Waves appear to have cut the lower Atlantic benches whereas the Pacific coastal bench is essentially a surface of subaerial denudation, though it may have been modified by the sea. The ancestral forms of the present coastal bench may be traced to the earlier part of the Pleistocene, for west of Bejuco the bench disappears under a tuffaceous formation considered as Pleistocene in age.

The 330-foot bench in Chagres plateau does not appear on the Pacific side, nor the deeply entrenched streams. Uplift was therefore greater on the Atlantic side. Tilting is further suggested by the difference in the depth of the shoulders of the continental shelves. The shoulder of the Atlantic shelf occurs at the depth of 42 fathoms, whereas on the Pacific side it lies at 72 fathoms below sea level.³¹ However, the inclination of the Pacific coastal bench was affected by the movement. Streams are incised though much less deeply than those in Chagres plateau.

In spite of the greater uplift on the Atlantic side, the Pacific coastal bench, because of its gentler gradient, reached further out to sea. The evidence of the submarine profile (Figure 12) indicates that sea level was lower by at least 80 feet, which means that the Pacific coast line opposite the canal entrance extended at least eight miles beyond its present position. Since the Pearl Islands are separated from the Pacific coast by a channel with minimum depths of 100 feet, it is possible that they were connected with the mainland prior to the last major rise of sea level. Pearl Islands are 25 miles offshore. On the Atlantic side, a drop in sea level by 80 feet would add a strip of land only one and a-half mile wide to the base of the Chagres plateau.

The last rise of sea level, perhaps during the last deglaciation, was rapid and covered the weathered surfaces of the coastal bench. At its maximum height the sea rose beyond the present shore line and reached into bays and inlets, where muck accumulated in brackish water. On the exposed coast, the sea was in contact with the steeper gradients of the upper parts of the denudational plain, where sea cliffs and scarplets that bound the outer edges of the present coastal bench were probably initiated. The subsequent retreat of the sea by about 10 feet produced features such as swamps of muck, dead coral platforms and stranded marine platforms.

The relative stability of the present sea level is suggested by the extent of coastal modification that the sea is able to achieve in its present position. Both regressional and progradational changes in coast lines have taken place since the sea reached its present level. Regression results in cliffed coasts, such as where the tuffaceous flank of El Valle reaches the set, and on the Atlantic side, in the sandstone of Chagres plateau. The cutting of El Valle sea cliff takes place *pari passu* with the construction of spits in opposite directions on either side. Thus the lower course of the Río Farallón on the west and of the Río Chame on the east have been deflected by sand ridges that are densely forested, and rise 10 to 25 feet above the level of the mean tide. Recent beach sand, covered by water during high tide, has been added to these ridges. More extensive progradation appears east of Old Panama. Here the coastal bench ends in a grass-covered scarplet; beyond it spread tall-grass swamps between coconut-crowned sand ridges

³¹ Terry, *op. cit.*, p. 16.

with comparable elevations above sea level (maximum: +25 feet), and the mangrove swamp at the edge of the sea. The width of this progradational plain increases eastward from a narrow edge just east of Old Panama to about seven or eight miles at Río Chepo. Progradation was probably punctuated by shorter phases of regression. Thus the present coast line bears evidence of erosion in the cakes of old mud flats at Juan Diaz and in the clifflets cut in sand ridges. However, beyond them are broad deposits of new mud, exposed only during low tide. Progradation, apart from the mud that collected on coral flats, has been much less extensive on the Atlantic side. Forested beach ridges occur, for instance, in the vicinity of María Chiquita but they are much smaller and narrower than the Chame and Farallón ridges.

Marine erosion is now the dominant process operating on both shores of the Panamanian isthmus. This is illustrated by beaches littered with drift wood especially on the Atlantic side, and by the ubiquitous beach scarps. More striking examples of beach erosion occur on both shores. Thus the mouth of the Río Chagres on the Atlantic side is partly blocked by a spit. A paved road that used to run along it is now crumbling into the sea. On the Pacific side, the mud cakes east of Juan Diaz, and the precarious stands of mangrove in heavy surf at Camarón west of the Canal Zone, are clear manifestation of erosion.

THE WEST INDIAN HIP-ROOFED COTTAGE*

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Among the several types of houses found in the West Indies is a distinctive cottage (Figure 1). The ubiquitous presence of this cottage on all islands except Cuba and Puerto Rico, despite differences in nationality, arouses curiosity about its origin, especially in view of recent statements tending to indicate relatively little contact between West Indian islands.¹ The evidence suggests that the house probably originated within a hundred miles of the English Channel, that it was first introduced into the islands between 1625 and 1700, and that it has been re-diffused among the islands in complex patterns since.

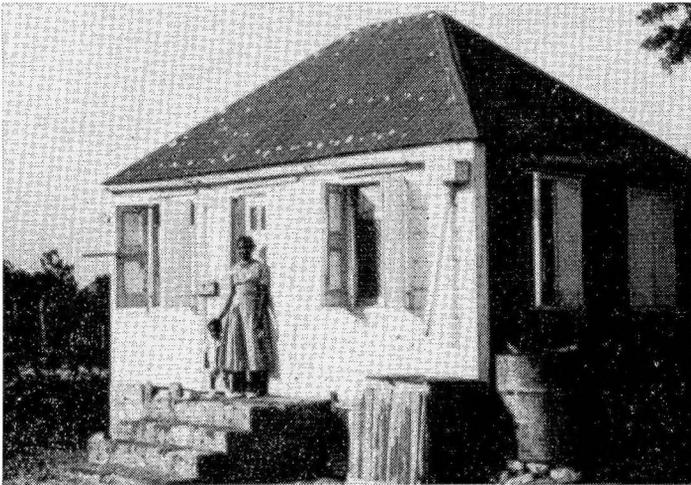


Fig. 1

* This is a preliminary study of a previously nearly untouched aspect of West Indian cultural geography. As such, and because of a major methodological weakness, this paper must be prefaced by an explicit reservation. In no case was the period of field work long enough to permit inspection of house interiors in more than a statistically negligible number of examples, hence the plans of houses and arrangements of rooms are little known. Second, in order to obtain any feeling for the West Indian distribution of house types, a subject on which there is almost no literature, it was necessary to rely very largely on photographs, many of them taken from a considerable distance and showing only the general shape of the house. As a result it might be argued that the phenomenon under consideration is not adequate to constitute a house type as such, but is simply one major facet of type recognition: the roof.

With the understanding that field analysis of house interiors is mandatory for fuller understanding, and recognizing that such study might answer some of the questions raised herein, we can consider roofs alone as a diagnostic feature and proceed as far as possible with this more limited criterion of cultural diffusion.

¹ J. P. Augelli, "The British Virgin Islands: A West Indian Anomaly," *Geographical Review*, Vol. 46, 1956, pp. 43-58; David Lowenthal, "The West Indies Chooses a Capital," *Geographical Review*, Vol. 48, 1958, pp. 336-364.

The two principal criteria which permit recognition of the house are the hip roof and its pitch of 35 to 50 degrees. A hip roof slants in four directions whereas a gable roof slopes in only two, a difference easily distinguishable even in photographs taken from some distance (Figure 2a). Pitch refers to the degree of inclination and usually is the same for all parts of a roof, since this makes for ease of construction. For present purposes pitches are classified as gentle (15-25 degrees), moderate (25-35 degrees), steep (35-50 degrees), and very steep (50-60 degrees) (Figure 2b, 2c). Although initially a clinometer was used in the field to measure pitches, it was soon possible to estimate them accurately enough to place them in the proper categories.

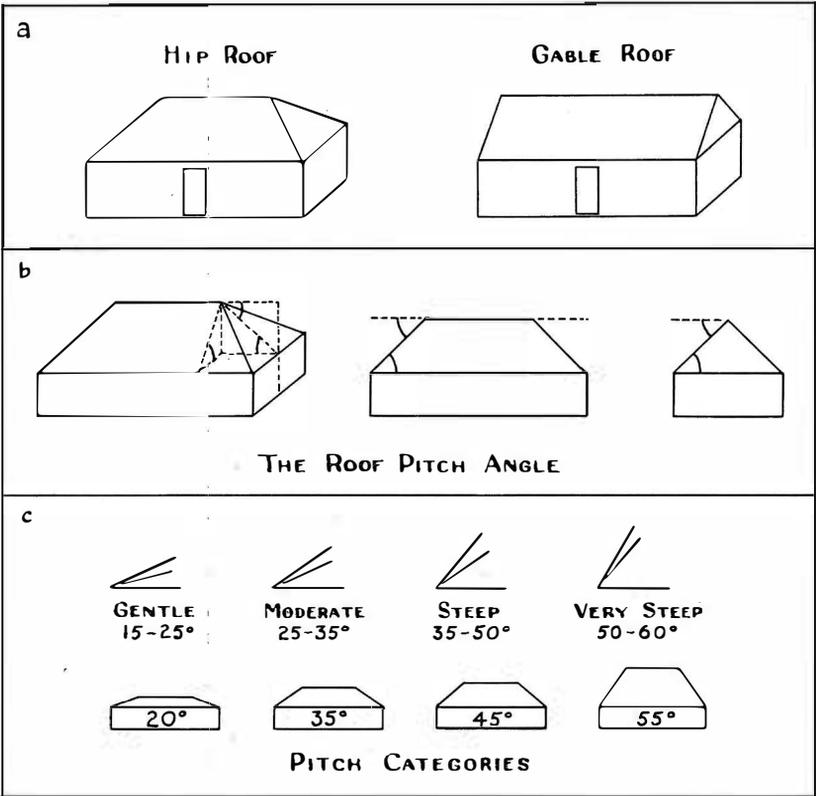


Fig. 2

The house is always rectangular in plan and frequently is twice as long as it is wide. If all four pitches are the same this plan results in a ridge which is half the length of the longer sides. In practically all cases the latter are considered the front and back of the house, and are oriented parallel to the street, the beach, or other thoroughfare.

Roof and wall materials vary and probably are not culturally diagnostic. Although there is some evidence to contradict the latter statement consideration of it must remain for future work. Roof coverings, which

may be thatch, shingles, or corrugated iron, often indicate a time sequence from older thatch roofs to newer iron ones. An analysis of this progression, based on field observation and data from several censuses, has been made for the island of Grand Cayman.² Similar comments on relative age are obtained from informants in the field.³ Walls may be constructed of wattle and daub, planks, shingles, or stone and, except for wattle and daub which is an older trait, seem to relate mainly to cheapness and availability of materials rather than to time or cultural antecedents.

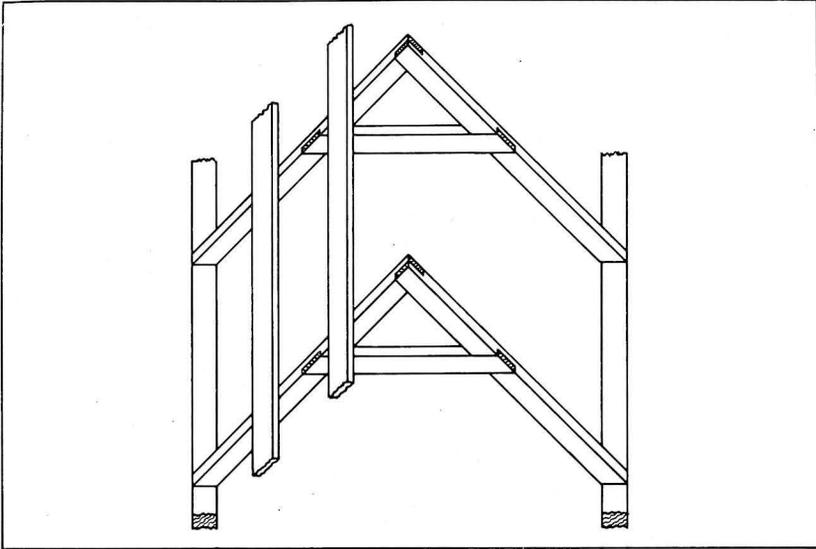


Fig. 3

Construction techniques are not known in any detail except for one example which seems significant. Rather than forming the roof by erecting a ridge pole to support the rafters a widely used procedure was to mortise pairs of rafters together into A-frames, to erect these on top of all wall plates without a ridge pole, then to secure them with horizontal purlins (Figure 3).⁴

The distribution of the hip-roofed cottage was determined by field analysis of houses in the Cayman Islands, Bahamas, Puerto Rico, and Leeward Islands and by examining photographs of all islands. From a qualitative standpoint the results are amply accurate, and simple enough. The hip-roofed cottage is essentially absent in Cuba and Puerto Rico and is found without exception on every other West Indian island.

² Edwin Doran, Jr., *A Physical and Cultural Geography of the Cayman Islands*, (Unpublished dissertation, University of California, Berkeley, 1953), pp. 277-280.

³ For example, from Mrs. Lesmora Creque, Virgin Gorda, B. V. I., Mr. Carris Penn, Tortola, B.V.I., and Mr. Burnstall Beazer, Barbuda, B.V.I.

⁴ Use of A-frame rafters was described to the author in 1949 by Capt. Arnold Foster, Cayman Brac, B. W. I., and in 1957 by Mr. Joseph James, St. Thomas, U. S. Virgin Islands, Mr. Carris Penn, Tortola, B. V. I., and by an unidentified informant of Antigua, B. W. I.

Places Mapped	1st Summary			2nd Summary			3rd Summary		
	Total	Hip	%H	Total	Hip	%H	Total	Hip	%H
Providencia, San Andrés				26	10	38			
Grand Cayman				406	65	16			
Jamaica				58	23	40			
Bahamas, Turks-Caicos				178	64	36			
Brit. inf., C & W. Carib. . .							668	162	54
Cuba				249	2	1			
Puerto Rico				212	6	3			
Cuba, Pto. Rico							461	8	2
Haiti				144	70	49			
Dominican Republic				82	21	26			
Hispaniola							226	91	40
U. S. Virgin Islands				173	75	43			
British Virgin Islands				269	185	69			
Saba	47	20	43						
St. Eutadius	62	26	42						
St. Kitts	49	36	73						
Montserrat	25	18	72						
Anguilla	75	36	48						
St. Martin	94	64	68						
St. Barthélemy	123	113	92						
Antigua	62	51	82						
Barbuda	33	22	67						
Leeward Islands				570	386	68			
Guadeloupe				31	7	23			
Martinique				112	36	32			
Dominica, Barbados	42	28	67						
Sts. Lucia, Vincent; Grenada	163	80	49						
British Windward Islands				205	108	53			
Trinidad				19	6	32			
Curacao				114	85	75			
Lesser Antilles							1493	888	60
WEST INDIES							2848	1149	41
West Indies				2848	1149	41			
Bermuda				42	27	64			
British Honduras				116	6	5			
Nicaragua				124	0	0			
New World							3130	1182	38
Spain				158	0	0			
Portugal, Madeira, C. Verde				140	39	28			
Iberia							298	39	13
Netherlands				94	38	40			
Normandy, Brittany				50	15	30			
England				47	30	64			
Circum-English Channel .							191	83	43
TOTAL HOUSES							3619	1304	36

Table 1. Distribution of the hip-roofed cottage.

Although the number of houses counted in the West Indies amounts to over 2800, this sample is not large enough to enable frequency of occurrence to be determined except as a first approximation. Islands on which the author has made field studies are represented, too, by counts which, in proportion to total population, are larger and hence more accurate than those obtained from photographs for the Greater Antilles and Windward Islands (Table 1).⁵ With these reservations one may say that the house

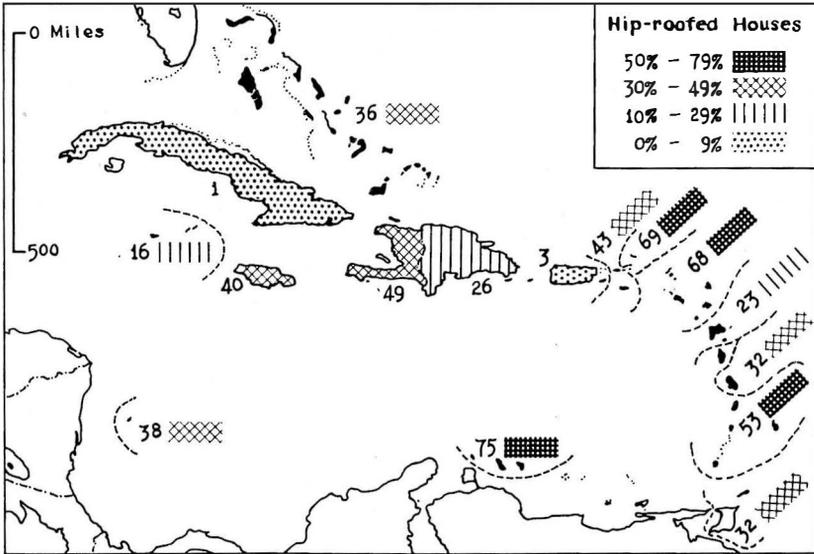


Fig. 4

occurs most frequently in the British and Netherlands West Indies, less frequently in Haiti, French West Indies and Trinidad, to some extent in the Dominican Republic, and hardly at all in Cuba and Puerto Rico (Figure 4).⁶ These data are quantitatively too inaccurate to pursue further here, but they arouse interesting speculations as to causes of the differences.

If one assumes that a house type is a cultural trait and that traits are more commonly invented only one time and then diffused to their known range rather than invented independently in multiple locations, then one may reason that there are four possible sources from which the

⁵ Duplicated lists of the 47 sources of photographs and data from which the figures of Table I were derived are in the hands of the author, from whom they may be obtained by the interested reader.

⁶ Certain anomalies and gaps in the distribution record must be recognized. In the Cuba and Puerto Rico of half a century past an appreciable number of steeply pitched, thatched, hip-roofed houses was noted but not counted as hip roofs because of very steep pitch and invariable Arawak-derived designation as *bohio* it is reasonable to suppose that they trace back to Indian rather than European ancestry. Although mainland Latin America is represented only by Nicaragua, a number of other localities were spot-checked without discovering hip-roofed houses of steep pitch, giving a reasonable supposition that they are absent. Spain itself provides no examples of the typical house, but Portugal has a few. In the Madeira and Cape Verde Islands, however, there are a number of houses indistinguishable from the type with which we are concerned. Their provenience is unknown.

idea of the hip-roofed cottage may have been derived. Let us consider the evidence for each source.

Spaniards occupied the Greater Antilles for over 150 years but were supplanted in Jamaica and Haiti in the latter half of the 17th century. Two hundred fifty to 300 subsequent years of English and French occupation have effectively removed most traces of Hispanic culture in these islands. Although Spaniards held on in what is now the Dominican Republic until about 1800, the east end of Hispaniola has since then been subjected repeatedly to cultural invasions from the Haitian part of the island which have left their marks in the landscape. Only in Puerto Rico and Cuba was Spain dominant until the 20th century, and here only is Spanish culture retained in significant proportion. While there are many hip-roofed houses in these islands, and in Spain as well, they are a Mediterranean version with roof pitches almost invariably less than 20 degrees. The origin of the cottage does not lie here, and the history of Cuba and Puerto Rico explains its absence on those islands.

The American Indian inhabitants of the West Indies were quickly eliminated from the 16th century scene except in minor numbers. Although their presence kept Spaniards away from the Lesser Antilles, and such useful Indian traits as cultivated plants were widely adopted, their cultural influence cannot be considered great. Some Arawak and Carib houses were circular or oval in plan and obviously are not related to the problem. While others were rectangular their roofs had pitches of 55 to 60 degrees and, although hipped in form, exhibited end slopes approaching gables in appearance.⁷ It seems safe, therefore, to eliminate the Indian as the source of the hip-roofed cottage.

The Negro slaves of colonial times, whose descendants now dominate the West Indies racially, were by and large obtained from one part of Africa, the Guinea-Congo Culture Area.⁸ In the region there is some use of a round house, which can be excluded from consideration here, but many types of rectangular houses also are built there. All are thatched, and some have hip roofs of moderate to steep pitch that cannot be differentiated from those of some West Indian hip-roofed cottages.⁹ Herskovits insists that West Indian Negroes have retained many African traits to the present,¹⁰ and one may thus reason that the houses they have built for themselves through the centuries may well have been patterned after those used in Africa. However, Herskovits states that all West African houses are built by tying rafters against a ridge pole.¹¹ Since the distribution of A-frame rafters in the West Indies, although widespread, is insufficiently known, an African origin of the hip-roofed cottage must be retained as a possibility.

⁷ Illustrated by Julian H. Steward, editor, *The Handbook of South American Indians*, Bur. of Amer. Ethnology Publ. No. 143, Vol. 4, p. 532.

⁸ Melville J. Herskovits, *The Myth of the Negro Past*, (New York: Harper, 1941), p. 295.

⁹ Many such houses are illustrated in R. S. Rattray, *Religion and Art in Ashanti*, (Oxford: Clarendon, 1927), pp. 34, 72, 118, 151, 186, 304; and Melville J. Herskovits, *Dahomey, An Ancient West African Kingdom*, (New York: J. J. Augustin, 1938), pp. 80, 96, 129, 144, 224, 385.

¹⁰ Herskovits, *op. cit.*, 1941, pp. 295, 296.

¹¹ Letter of February 27, 1958.

The fourth and last possible source of the house lies in an area around the English Channel, including English, French, and Dutch peoples, from which most of the early Northwest European migrants to the West Indies were derived.¹² Throughout this circum-channel area a steep to very steeply pitched hip-roofed cottage is still in use (Table 1).

As a result of some half a dozen historical studies of English architecture the antecedents of the English cottage are known rather well. Most houses in England were gabled until about 1600, after which hip roofs became more common. In fact, hip roofs are said to suggest the 17th century. Very steep pitches, of 50 to 60 degrees, gave way during that century to steep pitches of 45 to 50 degrees, but none are less than 40 degrees. Two sources mention the use of mortised A-frame rafters without ridge poles, and it is noted that hip roofs are best developed in the south of England and particularly in Kent and Sussex.¹³

Early comments from the West Indies also note similarities between local and European houses. The Dutch, in 1681 on St. Eustatius, had all the lodging facilities of Holland, while an "Indigoterie" of 1700 on Martinique is illustrated as having three buildings with hip roofs of about 40 degrees pitch.¹⁴ It is hardly likely that an establishment such as the latter would have been patterned after slave's ideas. Ligon is quoted in 1741 as stating that houses in Barbados were well constructed "according to the manner of building in England," and Hope Estate in Jamaica, about 1800, had a "long range of negro houses, like thatched cottages," which were evidently reminiscent of home.¹⁵ Additional support may be derived from two modern French authors who state categorically that house types on Guadeloupe, Martinique, and in Haiti can be traced back directly to Europe rather than Africa.¹⁶

The probability must be noted, however, that a complex diffusion and re-diffusion of this house type idea has been going on within the West Indies for the last 300 years. There is evidence to indicate substantial

¹² The south of England, East Anglia, and Normandy are often mentioned as home lands of the early settlers. For example, see Sir Alan Burns, *History of the British West Indies*, (London: Allen and Unwin, 1954), p. 187; Jean Gottmann, "The Isles of Guadeloupe," *Geographical Review*, Vol. 35, p. 189; and Eugene Revert, *La France d'Amérique*, (Paris: Editions Maritimes et Coloniales, 1955), p. 50.

¹³ This summary was compiled from the following: Harry Batsford and Charles Fry, *The English Cottage*, (London: B. T. Batsford, 1939); Martin S. Briggs, *The Homes of the Pilgrim Fathers*, (New York: Oxford, 1932); Stewart Dick, *The Cottage Homes of England*, (London: E. Arnold, 1909); Frederick Gibberd, *The Architecture of England*, (London: The Architectural Press, 1953); Basil Oliver, *The Cottages of England*, (London: B. T. Batsford, 1929) Margaret and Alexander Potter, *Houses*, (London: J. Murray, 1948); and Marshall Sisson, *Country Cottages*, (London: Methuen, 1949).

¹⁴ Charles de Rochefort, *Histoire naturelle et morale des Iles Antilles de l'Amérique*, (Rotterdam: Chez Reinier Leers, 1681), p. 57; R. P. Labat, *Nouveau voyage aux Iles de l'Amérique*, (Paris: Collections "Ailleurs," 1931), p. 48.

¹⁵ John Oldmixon, *The British Empire in America*, (London: J. Brotherton, J. Clarke, 1741), p. 14; and Frank Cundall, editor, *Lady Nugent's Journal*, (London: The West India Committee, 1939), p. 39.

¹⁶ Revert, *op. cit.*, p. 63; and Paul Moral. "La maison rurale en Haiti," *Les Cahiers d'Outre-Mer*, Vol. 10, p. 120.

amounts of inter-island communication, despite dividing lines of nationality, through out the West Indian history.¹⁷

To summarize: A distinctive type of hip-roofed cottage is found on all West Indian islands except Cuba and Puerto Rico. It occurs in greatest proportions on British and Dutch islands, but is found also in Haiti, on French islands, and in the Dominican Republic.

Spanish or Indian sources for the cottage can be eliminated. African origins, although unlikely, must be retained as a possibility until more evidence on construction details has been secured.

The most logical origin for the West Indian hip-roofed cottage is in the circum-English Channel area. From here, and particularly in the years 1625-1700 when the greatest numbers of indentured laborers were brought to the Indies, very likely came the notion that the newly popular hip-roofed cottage was the proper type of dwelling to build. The broad distribution of the house type today is an interesting example of the diffusion and persistence of a cultural trait and an obvious element in the landscape which bears witness to the historical development of the region.

¹⁷ Edwin Doran, Jr., "The Caicos Conch Trade," *Geographical Review*, Vol. 48, 1958, pp. 400, 401; *Idem*, "Cultural Connections in The Leeward Islands," *The Carribbean*, Vol. 11, 1958. pp. 274-277.

A NOTE ON THE CLASSIFICATION OF DRY CLIMATES IN THE KÖPPEN SYSTEM

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Recently there appeared in *The Professional Geographer* an article describing a set of "dichotomous keys" to be used by students in classifying climatic stations according to the system of Wladimir Köppen.¹ And although the keys are presented in such awe-inspiring comprehensiveness as to require a supplementary "Abbreviated Key," the author was struck by the fact that the letter and spirit of the scheme of classification is still misunderstood on a number of points, despite attempts by some American geographers to clarify Köppen's procedure.²

One may well be accused of straining at a gnat by producing yet another paper that is no more than an interpretation of a classification system of sharply limited utility. Still, the system is taught in introductory and advanced classes and most American texts concerned with climatology describe it in some detail. It may be useful, therefore, to try to clear up what the author considers to be minor errors that have accompanied the transliteration of the system into English and into English units of measure. Furthermore, the written³ and spoken words of the author's colleagues seem to reinforce his personal observation of the needless pain endured by students exposed to this simple system of classification. Much of the difficulty lies, it seems to me, with the overly-literal transposition from metric to English units of measure. These comments are largely addressed to this second point. Finally, the author would like to comment briefly on the inherent lack of logic in Köppen's formulation of the Dry-Humid boundary.

As a beginning, the type of error and the kinds of misunderstanding involved may be illustrated by a translation of the following passage from *Die Klimate der Erde*:

The following can serve as the simplest approximate definition of the limits of Deserts and Steppes; if r be the yearly rainfall in centimeters, t the annual temperature in °C, then, where the annual variability of t or r is small, r can be taken to be equal to $t + 33$ at the outer boundary of Steppe climates (that is, at the limit of B). However, where their variability is considerable, there, if r falls predominantly in the warm season, the boundary must be put higher, on account of the high evaporation; if r falls mostly in the cold season, it must be taken at a lower value. Appropriate thresholds are found

¹ Peirce F. Lewis, "Dichotomous Keys to the Köppen System," *The Professional Geographer*, Vol. XIII (1961), pp. 25-31. For a very similar scheme, see: Alfred H. Meyer, "An American Adaptation of the Köppen Classification of Climates," *Papers of the Michigan Academy of Science, Arts and Letters*, Vol. XXIII (1937), pp. 361-366.

² John B. Leighly, "Graphic Studies in Climatology," *University of California Publications in Geography*, Vol. 2 (1922), pp. 55-71; R. J. Russell, "Dry Climates of the United States," *University of California Publications in Geography*, Vol. 5 (1931), pp. 1-41; C. O. Sauer and J. B. Leighly, *An Introduction to Geography*, 6th ed., (Ann Arbor, 1932), p. 53, ff; C. W. Thornthwaite, "The Quantitative Determination of Climate," *Geographical Review*, Vol. XXII (1932), pp. 323-325.

³ Lewis, *op. cit.*, p. 25.

to be: $t + 22$ for marked winter rain, $t + 44$ for marked summer rain. The boundary between *BS* and *BW* is put where r decreases to one-half this amount.

As an example we take Yalta ($r = 48$, $t = 13$) and Simferopol ($r = 42$, $t = 20$) in Crimea, both with rain in all months, but mostly in the winter at the first station, and mostly in summer at the second, so that the constants of addition should be about 28 in the former case, 38 in the latter.⁴

In the margin of the world map, which appears as a fold-out in the same publication, the limiting value of r for Desert climates is listed as being $t + 16\frac{1}{2}$; the values for climates with marked summer or marked winter rains are implied, but not stated. Obviously $t + 16\frac{1}{2}$ is not equal to one-half of $t + 33$. Nevertheless, as Thornthwaite⁵ and Kesseli⁶ have pointed out, the erroneous transcription on the world map was used by several authors, not only in describing the system, but also in applying it to particular areas. All this is of academically historical interest only, but it points out the kind of mis-transcription that has plagued Köppen's classification because of editorial shortcomings in the original publications.⁷

More interesting is the apparent misreading of Köppen's intentions with regard to which of the three sets of limiting values are to be used under particular conditions of t and r . His statement that the median formula, $r = t + 33$, needs to be increased or decreased under certain conditions is clearly meant to apply only in those cases where there is considerable seasonal contrast in both rainfall *and* temperature. To be sure, it is the rainfall regime that is emphasized by Köppen, but both the phraseology and the logic of the situation indicate that, in places without summer-winter temperature contrasts, it is absurd to consider "winter" rains more effective than "summer" rains. And yet this proviso does not appear in the American literature the author has seen, even though Köppen repeats it in succeeding publications.⁸ In large part, the neglect is attributable to the fact that Köppen in later writings directs the reader to nomographs in which no reference is made to the use of the median formula (or corresponding nomograph) in cases of near isothermality (Köppen indicates an annual range of 10°C as a limiting value⁹).

⁴ W. Köppen, *Die Klimate der Erde*, (Berlin, 1923), p. 121. In this translation the author has changed Köppen's nomenclature slightly so as to maintain uniformity throughout this article. The symbol t has been used to represent the mean annual temperature in °C, and r for the mean annual rainfall in cm. The letters T and R represent the identical quantities, but expressed in °F and inches, respectively.

⁵ Thornthwaite, *op. cit.*, p. 324.

⁶ John E. Kesseli, "The Climates of California According to the Köppen Classification," *Geographical Review*, Vol. XXXII (1942), p. 476.

⁷ Another example of the confusion engendered by inconsistency in the original publication is the rendition of the boundary between s and f climates. In his *Grundriss der Klimakunde*, 2d ed., (Berlin, 1931), p. 129, Köppen sets this boundary where (among other things) the driest month receives 3 cm. of precipitation. In the *Handbuch der Klimatologie*, Band I, Teil C, (Berlin, 1936), edited by Köppen and R. Geiger, he repeats the same value on page C22 (as 30 mm.); but in the summary on page C43, he lists the criterion as 40 mm. As this is the only place the author has found the value of 40 mm. used by Köppen, it is assumed to be a misprint. A number of American authors use 3 cm. (or, rather, 1.2 inches) for the delimitation of these climatic types; others use 40 mm., 1.57 inches, or 1.6 inches.

⁸ Köppen, *Grundriss der Klimakunde*, p. 128; Köppen, *Handbuch der Klimatologie*, p. C21.

⁹ *Loc. cit.*

Another curious misinterpretation is also partly attributable to the prominent position of the nomographs as an aid in classification. In the second paragraph of the translated section, Köppen uses several examples to illustrate his method. It is clear from these examples that he does not restrict himself to the values 22, 33, and 44 as constants of addition in the formulae. In the case of Yalta, which has, in his words, rain in all months but mostly in winter, he uses neither 22 nor 33, but rather the intermediate value 28; for Simferopol with its slight summer maximum, he uses a value of 38, intermediate between 33 and 44. It seems obvious that he intends the formulae $r = t + 22$ and $r = \frac{1}{2}(t + 22)$ to apply only to cases with quite pronounced winter concentration of precipitation, and analogously with the other pairs of formulae. Places with intermediate seasonal distribution of precipitation are to be judged on the basis of formulae having intermediate values for the addition constants. The logical necessity for such interpolation is clearly pointed out by Van Royen¹⁰ and by Russell¹¹ whose ideas are used by Kendall.¹² However, Russell's analysis is not carried to its logical conclusion. To be sure he points out that if one shifts from a value such as $r = t + 44$, as the boundary line between Humid and Steppe climates, to a value of $r = t + 33$, for the same boundary line, there will be a discontinuity (an "offset" in Russell's words) along the isoline that is used to demarcate those places with predominantly summer rains from those with an even rainfall regime; but Russell solves this problem by substituting nine formulae for Köppen's three, instead of developing a single continuously applicable formula. Such a simple formula, in which one of the variables is a parameter of the seasonal distribution of precipitation, is presented later. Before proceeding further, however, it is necessary to outline briefly the historical development of the formulae used by Köppen to delimit Dry climates.

The following table indicates the amounts of precipitation that Köppen considered to mark the outer edge of the Steppe climates, at various stages in the development of the classification. The Steppe-Desert boundary was set, in all cases, at one-half the values for the Steppe-Humid boundary, so it is omitted.

Date of Publication	Boundary between Steppe and Humid Climates		
	Even rainfall regimes	Winter rain	Summer rain
1918 ¹³	$r = 2t + 20$, or $r = \frac{4}{3}(t + 20)$ $r = \frac{5}{4}t + 30$	Text, p. 197 Map, p. 240	None formulated
1919 ¹⁴	$r = \frac{5}{4}t + 30$	None formulated	
1923 ⁴	$r = t + 33$ For BS-BW boundary: $r = \frac{1}{2}(t + 33)$ $r = t + 16\frac{1}{2}$	Text, p. 121 Map, frontispiece	$r = t + 22$ $r = t + 44$
1928 ¹⁵	$r = 2t + 14$	$r = 2t$	$r = 2t + 28$
1931 ⁸	same as 1928	same as 1928	same as 1928
1936 ⁸	same as 1928	same as 1928	same as 1928
1953 ¹⁶	same as 1928	same as 1928	same as 1928

The table points out three things: first, the discrepancies in the 1918 and 1923 publications between criteria indicated in the text and those shown in the map legends; second, the similarity in form of all these formulae, the only difference between them lying in the value of the approxi-

mate empirical constants, and third, the rather cavalier treatment of the empirical constants. For instance, in the 1918 article, Köppen states that "within the limits of accuracy one can also say: $r = 2t + 20$ [instead of $r = 4/3(t + 20)$], and the limits on the map would not be changed thereby."¹⁷ The point to be made is that Köppen thought of these formulae as convenient approximations, no more, else he would never have equated $2t + 20$ with $4/3(t + 20)$.

The presently-used formula should, I think, be thought of in the same way. Its transliteration from $r = 2t + 14$ (for evenly distributed rainfall) into English units as $R = .44T - 8.5$ gives a rather false impression of the degree of accuracy inherent in the original, an impression never intended by Köppen. A formula with simple constants, such as $R = 1/2T - 12$, much better represents the spirit of the system, and approximates its metric counterpart closely enough when T lies between 30 and 80 (it gives values within 5% of $R = .44T - 8.5$ for $48 < T < 81$; and within 10% for $42 < T < 166$). This simplification does not, however, solve the problem of replacing three separate formulae for three different rainfall regimes with one continuously applicable formula.

As many authors have pointed out,¹⁸ Köppen is never entirely clear as to what he means by a climate with predominantly summer rain, or winter rain, or an even rainfall regime. But in the *Handbuch der Klimatologie* he is reasonably specific, at least about summer rain climates. The formula $r = 2t + 28$ is to be used only when "the fraction $\frac{r}{t + 7}$ is greater in the warm season than in the cold."¹⁹ In this instance, r and t refer to rainfall and average temperature for the respective six-month seasons, and not to yearly values, of course.

If we take Köppen's formulation, using the subscripts s and w to indicate precipitation and temperature in the summer and winter half-years, respectively, we get, for summer rain climates, $\frac{r_s}{t_s + 7} > \frac{r_w}{t_w + 7}$. This can

be written in the form, $\frac{r_s}{r_s + r_w} > \frac{t_s + 7}{t_s + t_w + 14}$; which yields values for

¹⁰ W. Van Royen, "The Climatic Regions of North America," *Monthly Weather Review*, Vol. 55 (1927), p. 319.

¹¹ Russell, *op. cit.*, p. 15, ff.

¹² Henry M. Kendall, "Notes on Climatic Boundaries in the Eastern United States," *Geographical Review*, Vol. XXV (1935), p. 120.

¹³ W. Köppen, "Klassifikation der Klimate nach Temperatur, Niederschlag und Jahreslauf," *Petermanns Mitteilungen*, Vol. 64 (1918), pp. 197 and 240.

¹⁴ W. Köppen, "Klimaformel und reduzierte Regenmenge," *Meteorologische Zeitschrift*, Vol. 36 (1919), p. 6.

¹⁵ W. Köppen and R. Geiger, *Köppen-Geiger Klimakarte der Erde*, 1:20,000,000, (Gotha, 1928).

¹⁶ Köppen-Geiger, *Klima der Erde*, 1:16,000,000, Darmstadt, (1953).

¹⁷ Köppen, "Klassifikation der Klimate," p. 197.

¹⁸ P. E. James, *A Geography of Man*, 2d ed., (Boston, 1959), p. 537, for example.

¹⁹ Köppen, *Handbuch der Klimatologie*, p. C21.

$\frac{r_s}{r_s + r_w}$ (the percentage of the precipitation that falls in the six months

of summer) that range from $>50\%$, where $t_s = t_w$ (any excess of summer rainfall over winter is considered enough to class the climate as having summer rains, if there is no seasonality of temperature), to $> 100\%$, where $t_w = -7$. These two extremes are rather absurd, but for $t_s = 25$ and $t_w = 5$ (i.e., t is about 15 and the annual range is 20°C) the required percentage of summer rainfall becomes about 73% . This gives a rough idea of what Köppen meant by summer rain climates, in terms of the proportion of the annual precipitation that falls in the summer. Köppen says nothing about the delimitation of winter rain climates. He may have meant the two sets of criteria to be symmetrical. James and others²⁰ have used 70% and 30% summer concentration of precipitation as marking off summer rain, even, and winter rain regimes. These values fit fairly well with the results obtained from Köppen's statement and calculated for something like average conditions of temperature.

If we now take the three Köppen formulae of 1928, or, rather, their nearly exact equivalents in English units of measure, $R = .44T - 14$ (for winter rain climates), $R = .44T - 8.5$ (for climates with even rainfall), $R = .44T - 3$ (for summer rain climates), and assume that the winter rain formula is meant to apply to places having $X\%$ of their rain in winter, the even distribution formula to places having 50% of their rain in winter, and the summer rain formula to places with $(100 - X)\%$ of their rain in winter, we can transform the three discontinuous equations into a single one, of the form $R' = .44T - a(P_w + b)$, where P_w is the observed winter percentage of rain at a particular place. The constants a and b can be computed so as to make R' equal to $.44T - 14$ when some appropriate value of X is substituted for P_w , R' becomes equal to $.44T - 8.5$ when 50% is substituted for P_w , and R' becomes equal to $.44T - 3$ when $(100 - X)$ is substituted. The following transformations result when various values of X are used (X being the winter rain concentration that is considered typical for winter rain climates):

For $X = 100\%$	$R' = .44T - .11P_w - 3.00$
For $X = 90\%$	$R' = .44T - .14P_w - 1.63$
For $X = 80\%$	$R' = .44T - .18P_w + 0.67$
For $X = 70\%$	$R' = .44T - .28P_w + 5.25$

These are rather more elaborate looking formulae than are wanted. Fortunately, when $X = 82.5\%$, R' is approximately equal to $.44T - \frac{1}{6}P_w$. The percentage, 82.5 , seems to be a reasonable value for X ; it implies that the typical concentration of rainfall in winter for winter rain climates is roughly half-way between the two limits, 70% and 100% . Furthermore it yields a formula for R' of only two terms, $.44T$ and $-\frac{1}{6}P_w$, both easily learned. A further simplification can be achieved by substituting the slightly grosser approximation $R'' = \frac{1}{2}T - \frac{1}{4}P$ for the nearly exact formula $R' = .44T - \frac{1}{6}P_w$.

²⁰ James, *op. cit.*, p. 537; Henry M. Kendall *et al.*, *Introduction to Geography*, (New York, 1951), p. 668.

From a pedagogical view, a lot can be said in favor of the formulation of R'' . The coefficients are as simple as could be wished for; the formula gives precisely the right impression of the kind of exactness that is meant to be implied—the very simple nature of the coefficients indicates that the formula is meant to be a useful approximation, no more; there is only one formula to remember in place of three; there is no longer any problem of which of three formulae to use, and the classification by means of the simple formula yields results not very different from those obtained by the more cumbersome and less logical scheme of three different formulae (or nomographs).

The major objection that can be raised against the attempt at simplification, aside from considering Köppen's formulations to be definitive and exact boundary values rather than convenient approximations, is that it makes for a lack of correspondence between the criteria used for classifying a station and the criteria used to construct the several world maps of the Köppen system currently in use. The simplest counter to this objection is some familiarity with the lines drawn on such world maps. On the 1953 Köppen-Geiger wall map,²¹ for example, there are some minor discrepancies between the limits of Desert and Steppe as drawn and those which might be drawn by applying the standard Köppen formulae to published climatic data.²² These differences are, in fact, slight enough to make them completely unimportant when considering the pattern of climatic regions on a world scale. The author has only drawn the Steppe and Desert boundaries as determined by the simple approximation, $R'' = \frac{1}{2}T - \frac{1}{4}P_w$, in Eastern Oregon and on the margins of the Sahara, west of Long. 10° E. In those places, the lines drawn according to the new formula accord better, in many cases, with those shown on the wall map, than the lines computed according to the conventional formulae! In any case, the differences are so slight (except possibly for the Steppe margin in Oregon) as not to be worth troubling about. This is not to say that the formula presented here gives a nearly exact boundary for Desert and Steppe climates. The only claim is that it is as good as the conventional ones, much simpler to use and learn, and can be used in conjunction with existing maps. After all, Köppen used essentially the same map to illustrate his system in his publications of 1918, 1923, and 1928,²³ even though he changed the formulation of the Dry-Humid boundaries in 1923 and in 1928. In fact, if we are to believe the legend of the 1918 map, the criteria used to delimit the Dry climates on that map and, therefore, on the maps of 1923 and 1928 as well (since they appear to have boundaries identical to those of the 1918 map), are different from *any* of the changing criteria indicated in the text of his articles!²⁴

²¹ Köppen-Geiger, *Klima der Erde*, 1:16,000,000, (Darmstadt, 1953).

²² Frederick L. Wernstedt, *World Climatic Data: Africa*, (State College, Pennsylvania).

²³ Köppen, "Klassifikation der Klimate," p. 240; Köppen, *Die Klimate der Erde*, foldout; Köppen, *Klimakarte der Erde*. See also, Köppen, *Grundriss der Klimakunde*, fold-out.

²⁴ The criteria listed in the margin of the map accompanying his "Klassifikation der Klimate" can be equated with the formula: $r = 5/4 t + 30$. This formula is not mentioned in the text of any subsequent publication, except in "Klimaformel." Yet the 1918 map seems to be the prototype for all later ones, except that of 1953.

When all this is said and done, we find that we have simplified the expression delimiting Dry from Humid climates, and have eliminated the possibility of offsets on a map. We have also taken care of a good number of the absurdities that are illustrated by the following hypothetical, but perfectly reasonable, pair of stations:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Temp. (°F) Both Stations:	45	48	53	59	67	72	75	72	67	61	53	48	60
Precip. (in.) Station A:	2.0	1.6	1.3	1.0	0.7	0.2	0.0	0.4	1.0	1.3	1.8	1.9	13.2
Station B:	2.1	1.7	1.4	1.2	1.1	1.1	1.2	1.2	1.2	1.4	1.9	2.0	17.5

The two stations have identical annual marches of temperature but slightly different precipitation regimes. Station A receives 9.9 inches (or 75% of its total precipitation) in the winter six months. Station B receives 10.5 inches (or 60% of its total) in winter. Stations with more than 70% of their rainfall in winter are to be classified as having winter rain climates for purposes of defining the Humid-Arid boundary.²⁵ Hence we apply the criterion $R = .44T - 14$ to station A, and $R = .44T - 8.5$ to station B. The value of the first criterion is 12.4; and station A is therefore classified as *Csa*. The value of the second criterion is 17.9; and station B is classified as *BS*. We have managed to classify, as Dry, a station that receives in every month more rain than a station which we consider to be Humid!

For a similar situation that is not hypothetical, consider the climatic data for Carson City, Nevada, and Antelope, Oregon. Carson City receives 8.3 inches of precipitation in winter, or 78.5% of its annual total of 10.6 inches. Antelope receives only 0.4 inches less in winter than does Carson City, but this is only 63.5% of its annual total, which is 12.5 inches. Hence Carson City is classified as *Csb*, whereas Antelope despite higher precipitation and slightly lower temperature is called *BS*.

The formula here suggested avoids the great majority of such absurdities, though it is possible to imagine extreme cases in which even a continuously applicable formula fails to discriminate properly between stations. The reader may readily verify this by inventing examples in which one station is classified as Dry, whereas another, with the same temperatures and lower rainfall throughout the year, is classified as Humid.²⁶

The problem lies not only in the fact that there are three formulae, discontinuously applicable, but also in the very nature of the formulae. Köppen's language and the interpretation of the American writers on this subject all give the impression that what counts in determining the effectiveness of a particular amount of precipitation is the proportion that falls

²⁵ James, *loc. cit.*; Kendall, *Introduction to Geography, loc. cit.* Trewartha, in *An Introduction to Climate*, 3rd ed., (New York, 1954), p. 382, uses a 3:1 ratio between the rainfall of the extreme months to mark off winter rain climates, and a 10:1 ratio for summer rain climates. The hypothetical stations of the example fall into the same categories whether James' or Trewartha's criteria are used.

²⁶ To satisfy the conditions stated, the following inequalities (among others) must be satisfied: $R' < \frac{P'_w}{4K} < 25$; and $2R' (K + 1) < T < P'_w \left[\frac{1 + K}{2K} \right]$ where $K = \frac{R''}{R'}$, and the superscripts ' and '' identify the climatic values for the drier station that is classified as Humid, and the wetter station that is classified as Dry, respectively.

in a given six-month season. But, as the examples above are meant to demonstrate, it is quite possible for a high percentage of a relatively low annual total, at one place, to fall in one six-month season and yet be less than a lower percentage of a relatively higher annual total at another place. What is important is not the percentage of rain that falls in a given season, but rather the amount that falls under given conditions of potential evapotranspiration (for which temperature is implicitly used as a parameter in the Köppen formulations). The problem of improving Köppen's formulation while retaining the simple and easily-computed character of his delimiting criteria needs to be considered further. For the moment the author can only call attention to the logical absurdity inherent in the formulation as it stands.

TOPOGRAPHIC EFFECTS OF GLACIAL LAKE MISSOULA: A PRELIMINARY REPORT

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Pleistocene glaciation directly and indirectly affected much of western Montana. Most of the individual ranges in this part of the state supported alpine glaciers and lobes of the Cordilleran glacier of western Canada pushed into northwestern Montana at several places. One huge finger of ice came down the intermountain depression in northern Idaho and British Columbia known as the Purcell Trench (Fig. 1). The point of southernmost advance of the Purcell lobe is problematical, but it was at least as far as the south shore of Lake Pend Oreille. The ice was more than 2,000 feet thick in the vicinity of the lake, and one of its major effects was to block the Clark Fork River drainage where it emerges from the mountains a few miles west of the Idaho-Montana border. This damming of the Clark Fork Valley brought into existence Glacial Lake Missoula, which at its maximum extent covered most of lowland western Montana. At its highest stand the surface of the lake was approximately 4,300 feet above present sea level.

In terms of physiographic evolution, the existence of Lake Missoula has been the most recent significant event in the western part of the state. The "drowned" terrain can be expected to reveal the effects of such a great body of water. The purpose of this study is to examine the morphologic consequences of this impressive inland sea. The present report summarizes results obtained to date.

Occasional suggestions of the presence of a large lake in western Montana are encountered in the literature before the turn of the century, but the earliest comprehensive account of Glacial Lake Missoula, by Pardee, appeared in 1910.¹ This pioneering paper, described in considerable detail the gross features of the lake, its approximate extent, the site of the necessary ice dam, and a number of its physiographic effects.

Following Pardee's initial work, however, few geomorphologists have given attention to Lake Missoula. It is discussed briefly in the *Guidebook of the Western United States*² and William Morris Davis³ mentioned some of the lake's physiographic effects in a paper dealing primarily with direct glacial action in western Montana and northern Idaho. In a series of articles on the channeled scablands of Washington, J. Harlan Bretz⁴

¹ J. T. Pardee, "The Glacial Lake Missoula," *Journal of Geology*, Vol. 18 (1910), pp. 376-385.

² Marius R. Campbell and others, *Guidebook of the Western United States: Part A, The Northern Pacific Route*, U. S. G. S., Bull. 611 (1916).

³ W. M. Davis, "Features of Glacial Origin in Montana and Idaho," *Annals, Assoc. Amer. Geog.*, Vol. 10 (1921), pp. 75-148.

⁴ J. H. Bretz, "Channeled Scablands of the Columbia Plateau," *Jour. of Geol.*, Vol. 31 (1923), pp. 617-649; *idem*, "The Spokane Flood Beyond the Channeled Scablands," *Jour. of Geol.*, Vol. 33 (1925), pp. 97-115, 236-259; *idem*, "Channeled Scabland of Eastern Washington," *Geog. Review*, Vol. 18 (1928), pp. 446-447; *idem*, "Valley Deposits East of the Channeled Scabland," *Jour. of Geol.*, Vol. 37 (1929), pp. 393-427, 505-541; *idem*, "Lake Missoula and the Spokane Flood," *Bull., Geol. Soc. Amer.*, Vol. 53 (1942), pp. 1569-1600.

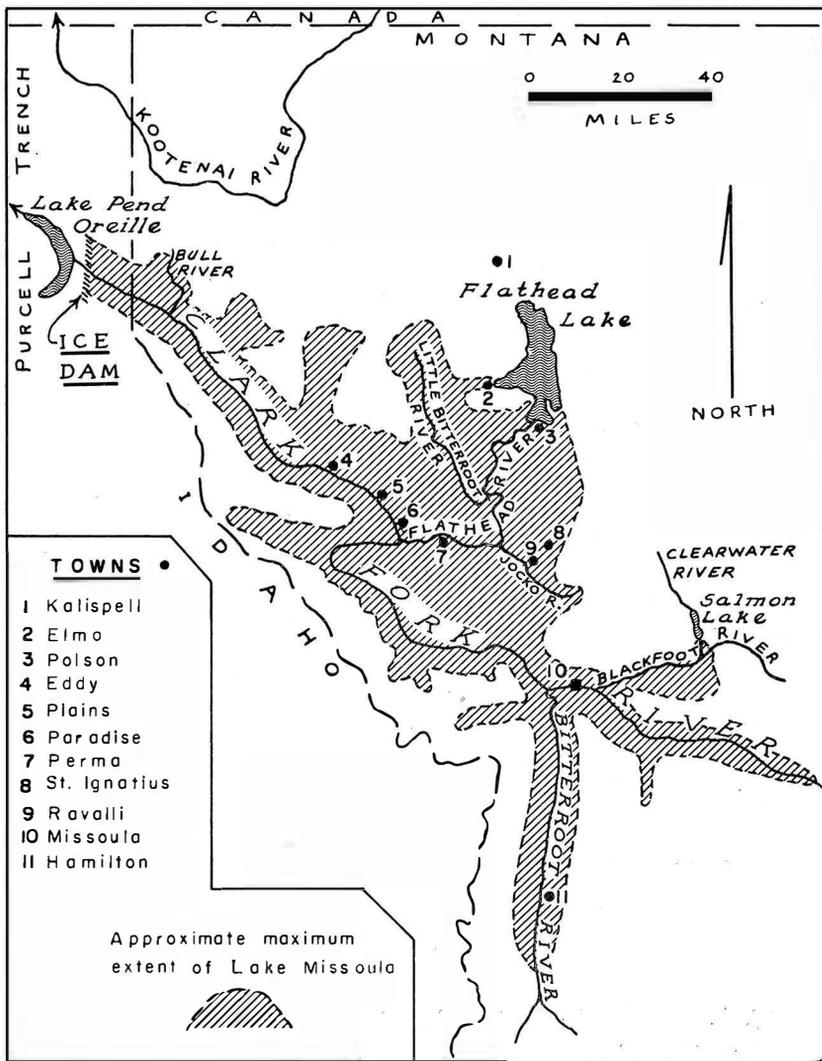


Figure 1. Index map of area of Glacial Lake Missoula, western Montana.

noted the necessity for a glacially dammed body of water to provide the runoff responsible for the extreme dissection of that part of the Columbia Plateau.

Pardee made another major contribution with his classic study of the effects of a rapid draining of the lake,⁵ in which a rough calculation showed that most of the 500 cubic miles of impounded water could have been released in less than two days. The "unusual currents" thus produced—to use Pardee's term—brought about notable topographic effects within the basin of Lake Missoula.

W. C. Alden⁶ discussed the lake in some detail in a report concerned chiefly with glaciation in western Montana, in which alternative explanations for some of the land forms described by Pardee were offered.

Finally, Bretz *et al.*⁷ published what appears to be the definitive study of the Washington scablands. The morphology of the scablands tract demands flood waters of enormous volume but short duration and Bretz and associates demonstrated convincingly that only a sudden draining of Lake Missoula could have provided the necessary inundation. They postulated a series of major floods, rather than only one great rush of water as implied by Pardee in 1952.

Against this background of former studies the present investigation is set. The object is a recognition and understanding of all the morphologic effects of the lake.

Glacial Lake Missoula produced a wide range of physiographic features. Discussed below are land forms mentioned in former studies or identified in the field in the course of this writer's investigation. In no way are the descriptions to be considered complete. They give only some idea of the different topographic forms related directly or indirectly to the existence of the lake.

Beach Lines. The most widespread of the topographic effects was the cutting of beach line terraces on slopes within the lake basin. Beach lines are seen in the following localities: Missoula Valley; Bitterroot Valley; Big Draw west of Flathead Lake; Jocko Valley; Nine Mile Prairie; Flathead Valley; Little Bitterroot Valley; Clark Fork Valley around Plains; and in many other isolated places.

The highest recognizable terrace is about 4,200 feet above present sea level. No single beach line has been traced horizontally for more than a few hundred yards because the topographic expression of terrace remnants is generally poor. No single terrace is conspicuously better developed than any of the others. The relatively slight slope indentations suggest that the level of the lake must have fluctuated more or less continuously.

The most impressive development of terraces was on slopes adjacent to long arms of the lake on which prevailing winds could generate large

⁵ J. T. Pardee, "Unusual Currents in Glacial Lake Missoula, Montana," *Bull., Geol. Soc. Amer.*, Vol. 53 (1942), pp. 1569-1600.

⁶ W. C. Alden, *Physiography and Glacial Geology of Western Montana and Adjacent Areas*, U. S. G. S. Prof. Paper 231 (1953), pp. 154-165.

⁷ J. H. Bretz, H. T. U. Smith, and G. E. Neff, "Channeled Scabland of Washington: New Data and Interpretations," *Bull., Geol. Soc. Amer.*, Vol. 67 (1956), pp. 957-1050.

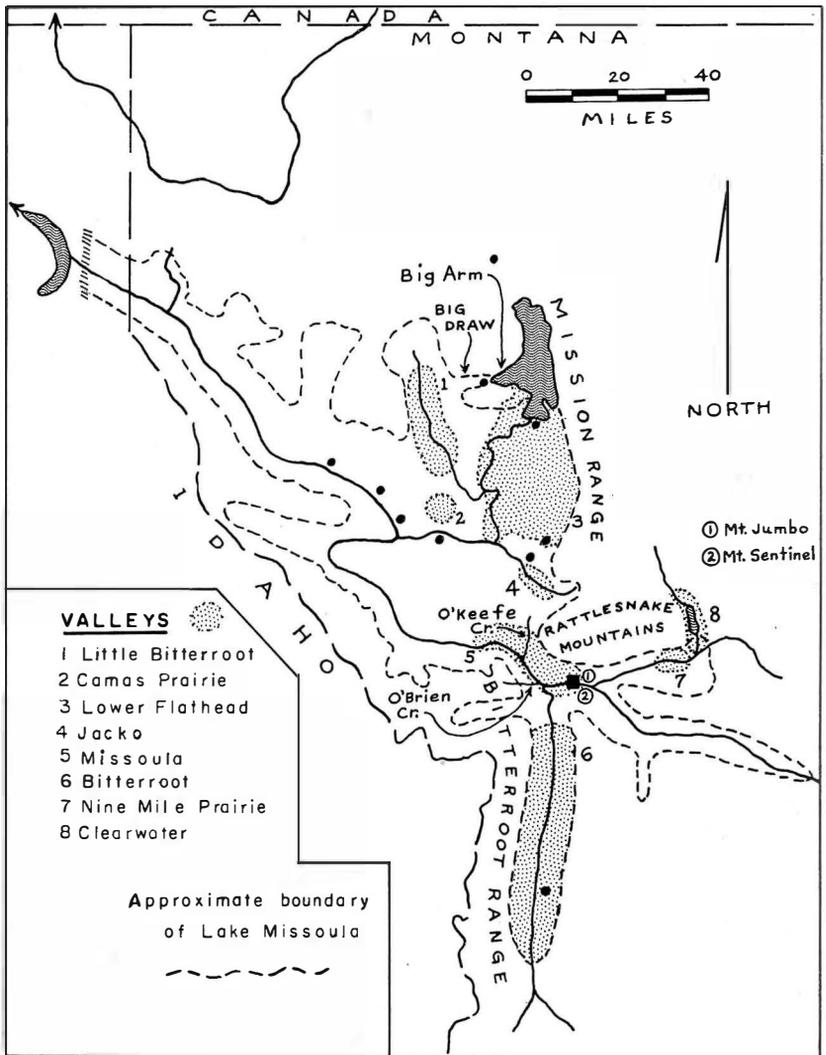


Figure 2. Location of specified features within basin of Glacial Lake Missoula, western Montana.

waves. The most spectacular terraces seen during the present investigation are along the south side of the Clark Fork River west of Missoula, where railroad embankment-like treads have been cut in bedrock.

Numerous problems are encountered in a consideration of the terraces, particularly problems of time relationships between glacial advances and the existence of Lake Missoula. For example, beach lines are found on numerous glacial moraines within the basin. Well-preserved shore lines on the moraines suggest a comparatively late stand of the lake. It seems probable, therefore, that advances and retreats of the larger lobes of ice occurred at different times and at different rates. The Flathead and Purcell Trench lobes must have operated more or less independently, and the glacier that invaded Nine Mile Prairie (Fig. 2) from the Clearwater Valley very probably was out of synchronization with those farther west. Similarly, the development and recession of alpine glaciers probably did not parallel the advance and retreat of the larger Cordilleran lobes; this viewpoint, however, has been challenged.⁸

The apparently intricate time relationships between glacial advances and stands of the lake at various levels remain to be worked out. The widespread distribution of shore lines should be of assistance in piecing together an acceptable chronology.

Silt Deposits. Silts were deposited on the floor of Lake Missoula in much of its basin. They are found in the following localities: Missoula Valley, Jocko Valley, Flathead Valley, Little Bitterroot Valley, Nine Mile Prairie, Camas Prairie, and in scattered situations throughout the general area.

Silts are thickest and cover the largest areas in basins immediately adjacent to margins of the larger ice masses or on valley floors directly downstream from the most massive glaciers. Those in the Little Bitterroot Valley and in western Missoula Valley are thickest and areally most extensive. There is also a large body of silts in the lower Flathead Valley near the junction of the Jocko and Flathead rivers. The Bitterroot Valley and the Clark Fork Valley east of Missoula all but lack deposits of silt. In part this may be the result of post-Lake Missoula removal by stream action and slope wash, but it must primarily be the case because lobes of the Cordilleran glacier did not deliver their silt-laden meltwaters into these arms of the lake.

Silts are found on top of the moraine west of Elmo at the head of the Big Draw. Since beach lines in the Big Draw itself are well above the upper surface of this moraine, it is obvious that the lake once extended east of the moraine. The Flathead lobe of ice must have receded before the Purcell Trench lobe, as has been suggested above. A complication is added in this part of the Lake Missoula basin by the fact that there are no silts in the Big Draw proper.⁹ This former outlet of Flathead Lake is floored entirely with much coarser glacial outwash; the coarse outwash disappears beneath silts in the northern Little Bitterroot Valley several miles to the west.

⁸ L. H. Nobles, "Glacial Sequence in the Mission Valley, Western Montana," *Bull., Geol. Soc. Amer.*, Vol. 63 (1952), p. 1286.

⁹ O. E. Meinzer, "Artesian Water for Irrigation in Little Bitterroot Valley, Montana," *U. S. G. S., Water Supply Paper 400-B* (1917), pp. 9-37, ref. p. 16.

Other somewhat peculiar, isolated silt deposits are found in diverse parts of the basin, and a careful consideration of all of the evidence will be necessary before an acceptable timetable for the final extinction of the lake and the recession of the various larger ice masses can be formulated.

"Ripple Marks" in Camas Prairie. One of the most remarkable topographic features related to the existence of Lake Missoula is a series of ridge-like masses of gravel in Camas Prairies termed "giant ripple marks" by Pardee.¹⁰ Briefly, he believed the forms were created by powerful currents sweeping through Camas Prairie as Lake Missoula was rapidly drained. He postulated that the lake surface over Camas Prairie fell suddenly with respect to that in the adjacent Little Bitterroot Valley, and that a great rush of water through Camas formed the "ripple marks." Alden¹¹ has offered an alternative explanation for their origin. Bretz *et al.*¹² sustain Pardee's thesis and describe similar features of larger size in the channeled scablands of Washington. This writer has made only a brief reconnaissance of the Camas Prairie area and is not at present in a position to support or deny Pardee's ideas.

High Eddy Deposits. Another consequence of a rapid draining of Lake Missoula and the development of powerful currents was apparently the deposition of masses of debris in certain valleys tributary to the lower Flathead River and Clark Fork River trunk canyons. Several such debris masses are found between Perma and Plains (Fig. 1). They were called "high eddy deposits" by Pardee.¹³ He thought they were swept into the mouths of tributaries by the turbulent currents which rushed through constricted reaches of the trunk canyons. Pardee's ideas have recently been supported by Bretz *et al.*¹⁴ Alden¹⁵ called the deposits "gulch fillings" and thought they might represent bars or deltas. The U. S. Geological Survey's *Guidebook of the Western United States*¹⁶ termed them deltas. W. M. Davis¹⁷ erroneously indentified them as glacial moraines.

These features have not been examined carefully during the present investigation, and their origin remains in question. Certainly they are not moraines, nor do they resemble deltas in external form. The writer tends to accept Pardee's explanation, although more intensive field study remains to be done.

Degraded Slopes. In many of the narrows of the lower Flathead and Clark Fork canyons the valley walls as far as 1,000 feet above present river level are virtually devoid of regolith. The Perma, Paradise and Eddy narrows are conspicuous in this respect. In some places, especially upstream from Perma, the terrain at first glance appears to have been created by massive rock falls and bedrock landsliding on a large scale.

Pardee¹⁸ believed these slopes were degraded by the "unusual currents" generated by the catastrophic draining of Lake Missoula. Presumably

¹⁰ Pardee, *op. cit.* (1942), pp. 1587-1588.

¹¹ Alden, *op. cit.*, p. 96.

¹² Bretz *et al.*, *op. cit.*, pp. 980, 986, 1006, 1007, 1045.

¹³ Pardee, *op. cit.*, pp. 1589-1593.

¹² Bretz *et al.*, *op. cit.*, pp. 980, 986, 1006, 1007, 1045.

¹⁵ Alden, *op. cit.*, pp. 158-160.

¹⁶ Campbell *et al.*, *op. cit.*, p. 142.

¹⁷ Davis, *op. cit.*, pp. 126-127.

¹⁸ Pardee, *op. cit.*, pp. 1588-1589.

some of the debris in the "high eddy" deposits is upstream regolith concentrated and re-deposited by the currents. Davis,¹⁹ appealing to glaciation, professed to see in the denuded rock masses evidence of the abrasive action of ice. However, there is no supporting field evidence that glaciers occupied any of the trunk canyons east of the Idaho-Montana boundary, nor have satisfactory source areas for the postulated glaciers been discovered.

This writer reserves judgment on the degraded slopes. Granting a rapid draining of Lake Missoula, violent currents undoubtedly were present in the narrows, and it is accepted that at least some of the apparent removal of regolith was accomplished by these. However, other possibilities exist. For example, there is a conspicuous break in slope inclination at the upper limit of the denuded canyon walls, and it may well be that lower, steeper segments were partially degraded by immediately post-Lake Missoula mass movements. Regolith on the submerged slope facets would have been thoroughly saturated and would have lacked a protective vegetation cover. Gravity-induced movements could have stripped off impressive volumes of regolith in a relatively brief time.

Bedrock Channels and Depressions in Rim of Camas Prairie. The north, east, and northwest rims of Camas Prairie (Fig. 2) are notched by several passes, or windgaps, marked by high-elevation bedrock channels and depressions. Pardee²⁰ thought these features were cut by rapid, concentrated currents formed when the lake surface over Camas Prairie dropped suddenly. Without a doubt the features are water-cut, but this investigator is skeptical of a short-time origin. Bedrock is a tough, clinkery quartzite, and it is difficult to believe that such impressive forms could have been eroded by only brief spasms of current action.

Another possible explanation would involve a blocking of the Little Bitterroot River near its junction with the Flathead River by the the Flathead lobe of ice. That such a blocking took place was suggested by Alden²¹ and the writer has found questionable field evidence to support the contention. An independent lake would thus have been created in the Little Bitterroot Valley. It could have overflowed into Camas Prairie, and the water-cut features in the various gaps could have been eroded by current action over an extended period.

Deposits on West Slope of Mount Sentinel. The western slope of Mount Sentinel above the Montana State University campus appears to have been covered to varying depths by materials deposited during at least one of the high stands of Glacial Lake Missoula. An impression is gained that steep, V-shaped bedrock valleys on the slope had been filled almost to the brim, converting what must have been a highly irregular front into a comparatively smooth surface. Post-Lake Missoula gullying has scoured parts of the slope. The supposed process of deposition is not understood. Possibly there was slack water or eddying immediately downstream from the constricted Hell Gate channel just east of Missoula. The deposits on Mount Sentinel are thus perhaps akin to the "high eddy" deposits farther west in the trunk canyons of the Clark Fork and Flathead rivers.

¹⁹ Davis, *op. cit.*, pp. 126-127.

²⁰ Pardee, *op. cit.*, pp. 1582-1584.

²¹ Alden, *op. cit.*, p. 158.

Terraced Glacial Outwash. A series of alluvial terraces in glacial outwash is found in the lower Clearwater River drainage basin south of Salmon Lake (Fig. 1). In places as many as seven or eight matched terrace treads are seen along the river, which is flowing in a trench 100-150 feet below the highest outwash surface. The physiographic evidence suggests strongly that the terraces were cut by the Clearwater River as its level declined with the falling surface of Lake Missoula. It seems probable that a shallow arm of the lake once extended north at least as far as Salmon Lake. As Lake Missoula drained, its level dropped progressively and the newly established Clearwater River followed suit, trenching the poorly consolidated outwash south of Salmon Lake.

Erratic Boulders and Smaller Debris. Throughout the basin of Lake Missoula, erratic boulders and smaller materials are widely distributed. Most must have been rafted by icebergs as such widespread occurrence admits of no other mode transportation.

Source areas for the icebergs which transported the erratics were numerous. The largest masses of ice washed by the lake were in Flathead Valley and Nine Mile Prairie (Fig. 2). However, alpine glaciers entered Lake Missoula in the southern Bitterroot Valley and along the western flank of the Missoula Range, and lobes of ice from north of the international boundary were probably in contact with arms of the lake in a broad zone between Flathead Lake on the east and the Bull River farther west (Fig. 1).

The wide distribution of erratics, some of which are faceted and striated, confuses the matter of deciding where limits of glaciation may lie. Glacial limits are easily recognized along much of the perimeter of the lake, but in some places the outer boundaries of direct action are obscure. Striated and faceted boulders may reveal direct glacial deposition, or they may simply indicate stranding and wasting of debris-laden bergs. Any erratics below the 4,200-foot level may have been iceberg rafted.

Anomalous Depressions on Flanks of Missoula Valley. An unusual depression is found on the ridge between O'Brien Creek and the Clark Fork River six miles west of Missoula (Fig. 2). Its origin is not clearly understood. It resembles a typical sink hole in karst terrain, but the underlying bedrock is not limestone, nor is there other evidence of solution in the immediate area. In all probability it has come into existence as a result of deposition of an underwater bar across a small, tranverse tributary of O'Brien Creek.

A similar feature is found northwest of Missoula, one and one-half miles west of lower O'Keefe Creek. As seen from the air, this depression appears to be a topographic pocket formed when a shallow valley, draining toward the Clark Fork River, was blocked by subsurface deposition.

Both of these depressions are well below the level of the highest stand of Lake Missoula, and their somewhat curious shapes and positions seem to indicate an origin directly related to subsurface currents and deposition within the body of the lake.

Landslides. Glacial Lake Missoula may have contributed indirectly to the formation of landslides in the Clark Fork Valley immediately east of Missoula. There are two major landslide zones here, one on the south wall of Hell Gate Canyon, one on the northeast side of Mount Jumbo.

In Hell Gate Canyon a single, large slide or slump has occurred in which a piece of the Mount Sentinel massif has slipped down and toward the river. The slide is apparently situated on a fault zone.²² The immediate cause of movement was probably undercutting by the river. A contributory cause may have been saturation under the waters of Lake Missoula by which the structurally weak block would have suffered a further loss of cohesion.

The slide area northeast of Mount Jumbo is also located on a fault zone.²³ The hummocky, subdued character of the topography is possibly the result of submergence in Lake Missoula. Saturation of an already unstable zone of regolith, gouge, and shattered bedrock may have materially promoted the movements which created the present distinctive land forms.

Landslides are also found along the north side of the Missoula Valley on the grassy slopes flanking the Rattlesnake Mountains. This writer has seen only a limited portion of this region and cannot judge the extent of the slide area or its possible relation to Lake Missoula.

The major effect of Lake Missoula on slope stability would have been in the saturation of all regolith below the 4,200-foot level. A consequent loss of cohesion in the loosened debris above bedrock could be expected, and landsliding might thereby be favored. However, a proved connection between the existence of the lake and specific slides has not yet been demonstrated.

Deltas. It is reasonable to assume that many deltas would have been built in Lake Missoula. Known deltas are few, however, probably because the level of the lake fluctuated so frequently that large masses of debris simply never were deposited at one particular elevation.

It has been suggested that the accumulation of gravels in the mouth of Marshall Canyon a few miles east of Missoula is a delta.²⁴ Also, the unusual gravel deposits in tributary valleys along the lower Clark Fork and Flathead rivers have been identified as deltas.²⁵ These are the features called glacial moraines by Davis,²⁶ "high eddy deposits" by Pardee,²⁷ and "gulch fillings" by Alden.²⁸

It seems likely, however, that only very small true deltas were built in the constantly fluctuating Lake Missoula, and that most, if not all, have been destroyed or greatly modified by post-Pleistocene stream action and slope washings.

Moraines Deposited in Standing Water. The existence of Lake Missoula beach lines on glacial moraines in parts of its basin suggests that at least some may have been deposited in standing water. The rounded and smoothed appearance of the Polson Moraine, the Elmo Moraine, and the

²² John P. Wehrenberg, Ed., *Guide Book to Field Trips*, Geol. Soc. Amer., Rocky Mountain Section, 12th Annual Meeting, Missoula, Mont., p. 8.

²³ *ibid.*, p. 8.

²⁴ *ibid.*, p. 8.

²⁵ Campbell *et al.*, *op. cit.*, p. 142.

²⁶ Davis, *op. cit.*, pp. 125-126.

²⁷ Pardee, *op. cit.*, pp. 1589-1593.

²⁸ Alden, *op. cit.*, pp. 158-160.

terminal moraine in Nine Mile Prairie gives the impression of a subduing of a more rugged topography by water action. The large number of rounded cobbles and boulders, especially in the Polson Moraine, implies abrasive action by waves and currents, either contemporaneously with deposition or thereafter. In the upper Bitterroot Valley, lateral and terminal moraines of alpine glaciers of the Bitterroot Range have undoubtedly been smoothed and lowered by water action.²⁹ A rather careful discrimination will have to be made, however, between moraines modified after formation by wave and current action and those laterally deposited in the standing waters of the lake. Such a distinction has not yet been made in most parts of its basin.

A fair idea of the topographic effects of Glacial Lake Missoula has been attained during the course of this investigation, but a great deal of knowledge about the lake and its effects remains to be gained. Accurate time relationships—perhaps only relative rather than absolute—must be established. The degree of preservation of various topographic features within the basin must be correlated with such factors as slope orientation, bedrock type, depth of regolith, distance from active ice fronts, and geologic structure. The extent to which post-Lake Missoula gradational action has altered original forms is little known. A single field season, in short, has served only to outline the problems in a general way and to whet the intellectual appetite of the investigator.

²⁹ R. L. Konizeski, personal communication, 1961.

PROPOSED RELICS OF COASTAL ALLUVIAL FANS IN SOUTHERN CALIFORNIA

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Alluvium disposed along the margins of the land occupies a position of special interest to students of alluvial forms, of their origin and development. It is ordinarily spread on a surface formerly occupied by the sea, its margins are encroached upon by the sea, it is subjected to continuous attrition by the sea, and its outer margins are transformed into forms of marine erosion and deposition. Records of former positions of the sea, differing horizontally and vertically from the present, may be discernible on or in it.

Since coastal habitats have long been attractive to man, such terrestrial deposits as accumulate there may enclose and preserve evidence of his former presence, drawing thus also the interest of prehistorians.

Attention is given here to a particular depositional form, the alluvial fan, with regard to its development in a coastal setting. The incentive has been the appearance in recent years of studies of deposits described as relics of coastal fans, relating their accumulation and dissection to glacially controlled variation of sea level. These studies have in turn been generated by attempts to relate evidence of former human occupation enclosed by the deposits to a general chronology of Pleistocene climatic change.¹

HYPOTHESIS OF AGGRADATION AND DISSECTION OF COASTAL ALLUVIAL FANS

The essential features of the proposed hypothesis may be stated simply: recession of the sea from a cliffed coast exposes a platform on which terrestrial sediments may accumulate in the form of alluvial fans; a subsequent rise of sea level exposes such alluvium to erosion by the sea and a sea cliff is formed; this truncation of the fan deposits leads to entrenchment of the master stream and dissection of the fan; a subsequent lowering of sea level exposes anew a platform in front of the sea cliff on which a fan again takes form, dissection gives way to aggradation in the older fan materials, the erosion channels are filled and the older fan is gradually buried in a younger fan deposit; another phase of rising sea level repeats the dissection, and so on. Dissection is thus tied to rising sea level, aggradation to receding sea level.

There are two bodies of coastal alluvium in Southern California to which the essence of the above hypothesis has been applied. A small deposit near the Scripps Institution of Oceanography north of San Diego, referred to as the Scripps fan, has been treated at length by Carter. From topographic maps, this is part of a bench or sloping surface, 300 to 400 yards wide, with a back margin at about 100 feet at the base of a steep rise of as much as 250 feet to a higher mesa surface; the outer margin is, locally, an actively eroding sea cliff 25 feet high.

¹ George F. Carter, "Evidence for Pleistocene Man in Southern California," *Geographical Review*, XL (1950), pp. 84-102; and *Pleistocene Man at San Diego* (Baltimore: The Johns Hopkins University Press, 1957), particularly pages 20-21, 222-226, 236, 252. Phil Orr, "Radiocarbon, Mammoths and Man on Santa Rosa Island," Abstract in *Bulletin of the Geological Soc. of America*, LXVII (Dec., 1956), p. 1777; and "Late Pleistocene Marine Terraces on Santa Rosa Island, California," *Bulletin of the Geological Soc. of America*, LXXI (July, 1960), pp. 1113-1120.

Deposits underlying a prominent coastal terrace on the northwest coast of Santa Rosa Island have been the subject of intensive, not yet fully published, studies by Orr. From the topographic maps, this terrace has a back margin at about 100 feet, at the base of a steep rise of 150 to 200 feet to a higher dissected terrace surface; the width of the terrace varies from about 200 to about 500 yards and the foreslope is an actively eroding sea cliff 50 to 100 feet high. The slope of the surface along the axes of proposed fan remnants is estimated to be 50 to 100 feet per mile.

Carter's analysis adheres most closely to the above hypothesis in his earlier publication. In his later publication and in correspondence, Carter has made it clear that he regards the record of erosion and deposition to be more complex than a simple reading in terms of fluctuating sea level would allow, but that he still regards the sea as the major trigger setting off erosion and that rising sea level is a cause of fan dissection. Orr's analysis, as judged from his publication and from correspondence, follows the above hypothesis closely.

The critique presented here is focused on two aspects which are fundamental to the hypothesis, (1) that the existing bodies of sediment are remnants of former alluvial fans, (2) that vertical movements of sea level would control erosion and deposition of the deposits in the manner outlined. This may properly begin with consideration of some aspects of the form of alluvial fans and of processes responsible.

Process and Form. An actively developing alluvial fan is an aggradational surface; more accurately, it is a surface exhibiting an imbalance between erosion and deposition in favor of deposition, a surface of net deposition. The form is owing mainly to the action of the master stream, which contributes the fan materials. Certain aspects of the form may be deduced.

Deposition occurs first in the fan apex, or fan "head" area, owing to decrease in velocity, and thus transporting power, of the master stream.² The greatest rate of aggradation is in the fan head area, with progressively less deposition per unit area down the fan slope, with increasing area of deposition surface and decreasing grain size. Thus the longitudinal profile should be concave. This is a uniformly observed characteristic of existing alluvial fans. (It may be noted that the diagrammatic section shown by Orr for the reconstruction of Santa Rosa Island fanglomerates are drawn with straight or convex surface profiles).

The degree of imbalance between deposition by the master stream and erosion induced by locally generated runoff on the fan surface necessarily decreases down the fan slope as the area over which the sediments are spread increases. There is thus a limit to the fan area beyond which the fan will not be extended. This maximum size will be reached when the margin of the fan receives as deposit from upslope no more material that is removed from it by runoff of local rainfall.

² It is an oversimplification, though one commonly found in textbooks, to refer this loss of velocity to decrease of gradient. Since the master stream will ordinarily break up into distributaries on emerging from a confined channel, and since there is loss of water from the channels owing to seepage into the loose fan materials, the decrease in velocity on an actively aggrading fan is probably due more to decrease in volume than to any decrease in gradient; indeed, channel slopes above the fan head may frequently be less than gradients on the fan surface—see below.

So long as deposition continues dominant in the fan head area, there is a zone in the channel upstream from there in which net deposition changes to net erosion. Downstream from this zone the surface is building up; upstream from it the surface is being lowered. Clearly, this condition cannot persist *in situ*; either deposition must give way to erosion on the downstream side or erosion must give way to deposition on the upstream side. Fan surfaces frequently continue into the lower part of the confined channel above the fan head proper, so that an extension of the depositional area upstream is common. The part of the depositional surface in the channel above the fan head proper should exhibit a lesser gradient than that in the fan head area, since the stream volume should be greater in the confined channel than on the fan head and thus the critical velocity for deposition there would require a lesser gradient. For a fan in which the depositional surface has been thus extended upstream into the more confined channel, the longitudinal profile should exhibit a slight "S" shape, owing to decreased gradient above the fan head. An examination of topographic maps from central and southern California which show well-defined fan forms shows a high frequency of occurrence of this feature.³ For the Santa Rosa Island deposits, the alluvial surface extends a considerable distance up the major drainage ways above the coastal terrace; from the topographic maps, this extension appears to have a steeper gradient than the terrace.

A fan has a limited life as a wholly depositional surface. The fan head area cannot continue indefinitely as a depositional surface because of the continuous increase of gradient there; eventually, deposition must give way to erosion. Extension of the alluvial surface upstream from the fan head means progressively less material available for deposition on the lower slopes of the fan, tending toward a reversal of the depositional-erosional imbalance and a dominance of erosion by local runoff. Such changes will take place independently of any external changes which might affect stream flow, such as changes in climate, vegetation cover, or crustal movements.⁴ Such inherent instability may account for part of the erosional-depositional sequence observed in the Scripps and Santa Rosa Island deposits.

³ Comparison of slopes in fan head area and in channel above fan head for some well-defined fans in southern California:

Stream	Topographic map; contour interval	Estimated slope of alluvial surface, feet per mile.	
		Above fan head ^a	Fan head ^b
San Antonio Can. ^c	Ontario 15'; 80' 40'	200	260
Indian Wells Can.	Inyokern 15'; 50'	200	260
Lytle Creek	San Bernardino 15'; 80', 40'	130	160
San Gabriel	Pomona 15'; 50'	60	70
Ingraham Canyon	Solyo 7½'; 20'	45	90
Kern River	Bakersfield 15'; 20', 25'	7	8

a. Least slope of alluvial surface above fan head, in "fan head embayment."

b. Steeper part of alluvial surface along axis of fan in fan head area.

c. A classic example of alluvial fan form, used to illustrate the type in the United States Geological Survey Atlas of Physiographic Types, 1900.

⁴ This observation may be extended to alluvial surfaces in general; these are inherently unstable, deposition tending to increase the gradient downstream from the area of deposition, so that unless this is compensated for in some way, deposition must eventually give way to erosion regardless of any changes in runoff.

Form of Existing Remnants. Both Carter and Orr accept the deposits as remnants of alluvial fans without much, or any, explanation for that view. An inference would be that the deposits are so clearly fan remnants to the observer in the field as to require no further consideration of the assumption.

Though distinct fan forms are not clear on the topographic maps, both Carter and Orr have reported in correspondence that a fan form is clear to the observer in the field. This does not, however, dispose of the problem entirely. In both cases the assumed fan surfaces are part of a surface of similar elevation and slope which continues laterally well beyond the assumed fan head areas. The Scripps fan surface continues for nearly three-fourths mile south of the tiny drainage that fed it, without sufficient change in elevation to be expressed on the map (contour interval 25 feet).

On Santa Rosa Island, a number of drainage systems emerge onto, and their lower parts are cut through, the terrace surface. Toward the west these drainage systems diminish in size to insignificance, but the terrace, with back margin at about 100 feet, continues beyond, still mapped as fanglomerate.⁵ If streams of markedly different drainage area were building up fan deposits on an exposed former marine surface of uniform elevation, the rate of growth, laterally and vertically, of the separate fans would be quite different, so that at any given time during development the elevation of the fan head areas should vary considerably. A removal of the lower and middle parts of fans, then, would leave a remnant surface quite unlike a terrace and in marked contrast to the form which appears on Santa Rosa Island.

It is indicated, then, that the surface of the supposed fan heads is an integral part of a similar surface extending laterally well beyond the fan head areas. The evolution of the fan surface is inseparable from the evolution of the rest of the surface and the latter does not appear readily explainable in terms of fan forming processes. This is sufficient reason to doubt that the surfaces are unmodified fan surfaces; if they are modified, a consideration of the agent and process of modification would be of critical importance in the analysis.

Relation of Rising Sea Level to Cliffling. The second question, given the assumption that the forms are remnants of alluvial fans, involves the validity of the interpretation that (1) a rising sea level would form a sea cliff in the fan materials and (2) this would result in rapid dissection of the fan.

That a rising sea margin encroaching on the outer margin of an alluvial fan will produce a sea cliff in the fan materials is not immediately apparent. At least three variables are involved: the slope of the fan surface, the rate of rise of sea level, and the rate at which erosional forces at the sea margin eat into the fan deposit. The latter is quite complex in itself, having to do not only with erosive forces at the sea margin, but also with rate of aggradation of the fan surface. If the rate of rise of sea level is so adjusted to the other factors as to keep the sea margin on or near the fan surface (that is, approximately, a rate of rise equal to or greater than the rate of landward erosion multiplied by the tangent of the angle of slope of the fan surface), no sea cliff can form; instead, the sea margin should march up the slope of the fan, carrying before it beach ridges and dunes, and leaving

⁵ Orr, 1960, *op. cit.*, fig. 1.

behind and below it reworked fan deposits of subaqueous terrace form, with convex profile. From such a condition, a fall of sea level followed by a still-stand should result in the formation of a sea cliff, landward erosion of the sea going on continuously, regardless of any vertical movement.

Thus the hypothesis of fan margin cliffing owing to rising sea level should not be accepted without considerable elaboration.

Relation of Cliffing to Fan Dissection. An essential part of the hypothesis is that the formation of a sea cliff in the fan materials would cause entrenchment of the master stream and dissection of the fan, thus relating dissection to rising sea level. This also requires elaboration.

While the presence of a cliffed margin is undoubtedly a condition favorable to fan dissection, it may be worth noting that a change from deposition to erosion in the cliff area will not affect the stream regime in the fan head area unless the change works its way up to the fan head. The presence of a sea cliff in the fan materials should *eventually* result in entrenchment of the master stream through (1) headward erosion from the cliff by a master stream capable of carrying a well-defined channel out to the cliff, or (2) headward erosion from the cliff by subsurface drainage or locally generated runoff, with later exploitation of one of the erosion channels by the master stream.

If the erosion is done by the master stream, it is required that the stream maintain a well-defined channel out to the sea cliff. The probability of this decreases with increasing distance of the sea cliff from the fan head area, as the stream on an actively aggrading fan loses volume downstream through formation of distributaries and seepage.

In any case, the probability of rapid dissection of the fan head area as a result of cliffing is clearly minimal with the cliff near the fan margin, is greater the longer the cliff is in existence, and increases greatly as the sea cliff advances toward the fan head area.

The proposed reconstructed fan at Scripps and those on Santa Rosa Island have unusually long radii for their drainage areas, that at Scripps being about a mile for a small, single stream drainage area with a length of less than a mile. The proposed fans of Santa Rosa Island extend seaward five miles or more from drainage areas extending inland about four miles.

Under such condition, it seems likely that considerable time would be required for a sea cliff in the outer part of the fan to effect erosion and dissection in the fan head area. Since an important part of the hypothesis relates the time of fan head dissection to a time of rising sea level and thus to time of deglaciation, it may be noted that the potential dissection of the fan is geared to the *presence* of a cliff, regardless of whether the cliff is active or abandoned. This leaves open the possibility that the abandonment of a sea cliff through recession of the sea and before dissection of the fan head, could place the beginning of fan head dissection, and especially the continuance of it, with subsiding rather than rising sea level. Other possibilities of timing present themselves as readily.

Clearly the relationships, especially as to timing, are complex and not to be understood through a simple thesis of rising sea, cliffing and concomitant fan dissection.

Volume and Extent of Proposed Fans. The proposed fans, as reconstructed, appear unusually large compared to the drainage areas that produced them. Since the fan deposit was derived entirely from erosion in the

drainage area, a consideration of the volume of deposition as compared to the volume of contributing erosion should be an important part of the analysis. Several unknowns are evident, but even a rough approximation should suggest whether or not the two volumes are compatible.

In the estimate given here, I have considered that the relevant erosion in the drainage areas is approximately the volume of the valleys, that lowering of interfluves is a minor consideration. For the Scripps fan drainage and for the lower and middle parts of the Santa Rosa Island stream systems, the interfluves are flattish and their lowering would be insignificant compared to enlargement of the valleys. The upper part of the Santa Rosa Island drainage has narrower interfluves and the estimate there may be too low.

For Santa Rosa Island, the volume of valleys in the relevant area is estimated to be about 145×10^7 cu.yd. For the upper part with narrower interfluves the estimate is 82×10^7 cu.yd.; for the lower and middle parts, 63×10^7 cu.yd. The upper part has presumably been eroding most of the time since the Pliocene at least; with the proposed fans late Pleistocene, the duration of fan deposition would probably be not more than 10% of the duration of erosion; contribution of the upper part of the drainage area to fan deposit, allowing an addition for lowering of interfluves, might then be 10×10^7 cu.yd. For the rest of the drainage area the estimated volume of valleys is about 63×10^7 cu.yd.; stream courses here were also well established at the beginning of fan development, since the lower parts of channels were at or near the level of basal deposits in the fan head area. Since, in addition, the lower parts of the valleys were aggrading rather than eroding during much of fan depositional time,⁶ the assignment of one third the volume of the lower and middle valleys as contributing to fan building seems liberal; this would be about 20×10^7 cu.yd. The total estimated contribution of erosion in the drainage area to fan building is thus about 30×10^7 cu.yd.

Orr interprets the coalesced fans to have extended seaward at least 8000 yards⁷; the thickness in the fan head area is about 20 yards.⁸ If the slope were uniform, the minimum volume would approximate that of a half cone of 8000 yard radius and 20 yard altitude, about 67×10^7 cu.yd.; with a decrease in gradient downslope the volume would be less; 50×10^7 cu.yd. is a round number for a modest estimate. This space would, however, have been occupied more than once by fan material, there being remnants of at least three alluvial bodies in the Santa Rosa Island formation. Orr's illustrations suggest that the earlier members were as thick as or thicker than the latest⁹ and rose as high as the present terrace surface, suggesting similar seaward extent. Since a large part of these earlier bodies was removed and the space reoccupied by later deposits, the greater part of the space in question should have been occupied at least three times. Considering also surface erosion and channel cutting in the various bodies, a total required volume of deposit might be, conservatively, three times the above estimate of fan volume, or 150×10^7 cu.yd. This is five times the liberal estimate for contributing erosion.

⁶ *Ibid.*

⁷ Orr, 1956, *op. cit.*, (about 6 miles) and correspondence.

⁸ Orr, 1960, *op. cit.*, figs. 2-8.

For the Scripps fan, an estimate of the volume of the small contributing drainage area is about 1.6×10^7 cu.yd. The fan head is at the base of a 200-foot cliff; since the lower part of the stream channel at the beginning of fan deposition must have been near the level of basal deposits in the fan head, it may be assumed that the canyon was already begun and its lower part incised more than 200 feet at the beginning of fan deposition; the relevant volume was, then, considerably less than the present volume of the canyon; reducing by one fourth leaves 1.2×10^7 cu.yd. as a generous estimate.

If the fan extended out to the -100 foot contour as proposed by Carter, the radius would be about 1800 yards, according to the submarine profile here.¹⁰ The thickness of alluvium in the fan head area is estimated to be 30 to 40 feet.¹¹ The volume of a half cone with radius 1800 yards and altitude 12 yards is about 2×10^7 cu.yd. With a decreasing gradient seaward the volume would be less, say 1.5×10^7 cu.yd. This is, however, much less than the required volume of fan material. At least four bodies of alluvium occur in the fan;¹² each was truncated and dissected before the deposition of the succeeding material. The amount of removal of earlier fan materials is not gone into, but it seems clear that in Carter's interpretation we may assume removal of the greater part of the first two fans at least.¹³ The above volume should probably be multiplied by at least three to give a minimum estimate for the required body of alluvium; this gives 4.5×10^7 cu.yd., nearly four times the liberal estimate for contributing erosion.

The above estimates leave out the fact that the duration of time of *deposition* on the proposed fans is only a part (half?) of the total span of proposed fan history, the rest being periods of higher sea level and fan dissection, while erosion in the contributing drainage area was continuous. If this factor is included, the discrepancies suggested in the above approximation would be much greater, perhaps twice as great.

The proposed fans, then, seem impossibly large.

TOWARD ALTERNATIVE HYPOTHESES

I have questioned the interpretation that the existing alluvial bodies are remnants of former alluvial fans unmodified as to surface form, and that their dissection and alluviation would be regulated by rising and falling sea level as outlined in the proposed hypothesis. Some suggestions toward alternative hypotheses may be made.

It is important to note that what is certain with regard to the position of the sea margin prior to the formation of the sea cliff is the relative position in the horizontal, not that in the vertical. It is perfectly clear that the sea margin was formerly seaward of its present position, but one may reconstruct a sequence of former conditions with a static sea level, one progressively higher in the past, or one progressively lower in the past. In all cases the sea margin moves away from the land and the height of the sea cliff diminishes to nil. A major difference in the three reconstructions

⁹ *Ibid.*; figure 2 shows this as about 60 feet.

¹⁰ F. P. Shepard and K. O. Emery, *Submarine Topography off the California Coast* (Geol. Soc. of America, Special Papers No. 31), Plate 9.

¹¹ Carter, 1957, *op. cit.*, p. 252.

¹² *Ibid.*, pp. 222-226.

¹³ *Ibid.*, see particularly p. 236, p. 224, fig. 44A.

is the distance from the present shore of the condition of nil height of sea cliff; farthest away with progressively lower sea level in the past, closest with progressively higher sea in the past.

There is evidently no clear indication at all of the former extent seaward of the alluvium; the present alluvium may have merged with marine facies further seaward.

A series of events may be outlined which relates the accumulation of coastal alluvium and colluvium, an aggrading coastal plain, to *rising* sea level, the sea margin approaching the land but remaining on the depositional surface; terrestrial deposits are transformed into marine facies on the seaward side—a marine overlap. A reconstruction on such grounds has certain advantages: (1) it is capable of reducing two major difficulties inherent in the alluvial fan hypothesis—the surface form, which is more marine terrace-like than fan head remnant-like, and the required volume of alluvium; (2) it is in keeping with the fine texture of the alluvium, unusual in a fan deposit of such slope; (3) it is in keeping with the observation that the lower terrestrial member of the Santa Rosa Island formation has clearly been overridden by a higher sea level

The foregoing critique suggests some observations and data which need to be adduced to support the interpretation of the deposits as remnants of alluvial fans. This is critical if the interpretation of dissection and deposition of the alluvium depends on its having had original fan form. It seems probable, however, that quite different initial assumptions and interpretations may be supported. The problem does not seem to lend itself well to simplification and generalization.

A DESCRIPTIVE CLASSIFICATION OF SHORE LINES

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Studies of shore lines and shore line processes have neglected the development and use of descriptive classifications and have emphasized the use of genetic classifications. Genetic classifications are theoretical, consequently they change, and perhaps become more complex as more is learned about the subject to be classified. While the genetic systems have served as useful bases for studying processes of shore development, they have, because of their many complexities and theoretical nature, made shore line description exceedingly difficult. There are several distinct classifications, each with its critics and supporters. In this fluid situation of argument and disputed interpretation even an expert must proceed with caution in applying explanatory-descriptive terms to shores. It is the purpose of this paper to propose a preliminary descriptive classification of shores that, first, will be useful in their description, and second, will be helpful in research.

The classification that the author proposes stems from the belief that genetic classifications are not a satisfactory means of identifying shore zones¹ for descriptive purposes. During the course of several field seasons devoted to the investigation of marine terraces along the central California coast, the northeastern coast of Venezuela, the Netherlands Antilles, and on the coast of East Africa it has become more and more apparent that the classic Davis-Johnson² genetic classification of shore lines does not provide a satisfactory means of distinguishing between different types of shores. Evidence from marine terraces and alluviated or drowned valleys indicates that coasts on which emergence has been responsible for the form of the shore are probably rare and that submerged coasts vary so widely in appearance as to have no common descriptive qualities. For example, study of the marine terrace deformation along Monterey Bay, California, showed that this part of the coast had been steadily uplifted, certainly since the mid-Pleistocene.³ However, logs of wells drilled into the flood plain alluvium of the local valleys indicated that during the last deglaciation the sea rose at least 200 feet with respect to the land. Thus, despite rising land, the Monterey Bay coast has submerged shore although the normal embayments are absent since the drowned river valley have been filled with alluvium. Furthermore, the deformation of the marine terraces on Bonaire and Curacao shows the islands have been rising continuously since the

¹ As used here, shore refers to a zone of varying width extending landward to include the sea cliff, beach ridge or sand dunes and seaward to the outer edge of the low tide breakers. Coast refers to a zone of indeterminate width which extends inland from the top of the sea cliff or landward edge of the beach ridge or sand dunes.

² W. M. Davis, "The Outline of Cape Cod," *Proceedings of the American Academy of Arts and Sciences*, Vol. 31 (1896), pp. 303-332; D. W. Johnson, *Shore Processes and Shoreline Development*, New York, 1919.

³ C. S. Alexander, "The Marine and Stream Terraces of the Capitola-Watsonville Area," *University of California Publications in Geography*, Vol. 10 (1953) pp. 1-44.

early Pleistocene yet several drowned valleys on the islands are evidence of shore submergence.⁴ Both these examples of rising coasts presently have shores of submergence and though both are submerged the forms of their shores are quite different.

As Shepard⁵ correctly observed, the last deglacial rise in sea level was so great as to make invalid the emergent class of shores. This class is not successfully revived by Cotton's⁶ suggestion of a new basis of primary classification—"coasts of stable and mobile crustal regions." Along coasts of mobile regions the possibility does exist that the most recent diastrophic movements (which must have occurred since the last deglaciation) may well have resulted in emergence. However, observations on the coasts of northeast Venezuela and East Africa indicate that along those coasts where marine and stream terraces are absent it is very difficult to determine the presence or absence of late Pleistocene or more recent earth movement. It is apparent then that a classification based on the relative rise or fall of land is difficult, and, in some cases, impossible to apply correctly. There are other systems which do not emphasize land movement, but these too are difficult to apply in the field.

These other shore line classifications are all genetic to a varying degree, and they require considerable subjective judgement in their application. The following review recalls some of the more important attempts at shore line classification. One of the earliest mentioned was proposed by Richthofen.⁷ His system is based primarily on the relation of the coast (as used by Richthofen, coast includes shore) to the continental relief features, and secondarily on the vertical shore profiles and on the relation of the shore to secondary elements of land relief. These in turn can be subdivided according to the form of the vertical profile and the configuration of the coastline resulting from drowned valleys or alluvial deposition. Modifications of Richthofen's ideas have been used by others, *i.e.*, Suess⁸ in defining Atlantic and Pacific coastal types.

Shepard⁹ relies upon marine and non-marine agencies in his classification to distinguish two major classes: (1) young shore lines, where the configuration is primarily due to non-marine agencies, and (2) mature shore lines, where the configuration is primarily due to marine agencies. Subclasses are devised according to the type of marine and non-marine agency responsible for the configuration of the particular shore.

In one of the most recent genetic shore line classifications, Valentin¹⁰ considers both relative movement of the land and marine erosion and deposition. His system distinguishes two primary types, advancing and retreating shores. Any given shore is the result of the interaction of four agencies of coastal formation: the (1) relative uplift or (2) depression of

⁴ C. S. Alexander, "The Marine Terraces of Aruba, Bonaire, and Curacao, Netherland Antilles," *Annals, Assoc. Am. Geog.*, Vol. 51 (1961), pp. 102-123.

⁵ F. P. Shepard, "Revised Classification of Marine Shore lines," *Jour. of Geol.*, Vol. 45 (1937), pp. 602-624.

⁶ C. A. Cotton, "Deductive Morphology and Genetic Classification of Coasts," *The Scientific Monthly*, Vol. 78 (1954), pp. 163-181.

⁷ F. F. von Richthofen, *Führer für Forschungreisende*, Hanover, 1901, pp. 287-306.

⁸ E. Suess, *The Face of the Earth*, Vol. 2, Oxford (1906), pp. 201-207.

⁹ *Op. cit.*

¹⁰ H. Valentin, *Die Küsten der Erde*, Justus Perthes, Gotha (1952), pp. 47-58.

the land and (3) marine erosion or (4) deposition. Horizontal advance (outbuilding) of the shore represents the dominance of emergence and marine deposition over submergence of the land and marine erosion. Retreat of the shore results from the converse of these conditions. The primary types of shores are thus divided into two subtypes: the advancing class into shores of emergence and shores of deposition, the retreating class into shores of submergence and shores of erosion. These subtypes can be further subdivided according to the processes or agents involved in their origin.

Recognizing that genetic classifications, such as those mentioned, require trained personnel to apply them, Putnam¹¹ proposes a broad system that seeks to minimize interpretation by using simplified terms such as "sea cliff" and "stream eroded plain" to describe shore and coast features. The classification deals with both coastal zones and shore lines and so is separated into two major parts—"a classification of coastal types determined by major landforms" (including a zone five to ten miles inland from the shore), and a "classification of coastal types determined by shore features" (shore lines proper). Coastal types are distinguished according to the major land forms, structure, and lithology within a five-to-ten-mile coastal zone. These coastal types are further subdivided on the basis of the principal agents which have shaped their surfaces. The agents, in turn, are grouped according to the climate in which they operate most effectively. Shore lines are first divided into two types on the basis of constructional or destructional shore features, and these are then subdivided according to the agents responsible for the features. Despite the use of noncontroversial terms to describe coast and shore features, Putnam's classification is basically genetic and also requires a great deal of interpretation on the part of the user.

It is evident from the foregoing review that attempts to classify shores have developed largely in genetic terms. Genetic classifications however, do not provide adequate means of describing shores. Requiring interpretation of shore features, the application of genetic systems is necessarily restricted to persons well versed in shore and coastal studies. Furthermore, since interpretation is required, even expert application may be subject to question.

In view of the difficulties inherent in the genetic approach to shore line classification, a system based entirely upon shore form seems to have much to recommend it. This approach is not entirely without precedent. One of the elements used by von Richthofen,¹² the shape of the vertical profile of the coast, is descriptive. Albrecht Penck¹³ also proposed a classification in which some coastal types are distinguished mainly on the basis of their appearance. His criteria involve coastal outline, vertical profile, coastal composition and rock structure. The outline of shores may be smooth, embayed or lobed. Lobed refers to shores with broad, open bays or small gulfs as found on Peloponnesos or on Celebes. In vertical profile

¹¹ W. C. Putnam, "Classification and Identification of Coastal Zones of the World," *Coastal Geography Conference*, Office of Naval Research, Dept. of Navy (1954), pp. 63-71.

¹² *Op. cit.*

¹³ A. Penck, *Morphologie der Erdoberfläche*, Part 2, Stuttgart, 1894, pp. 546-605.

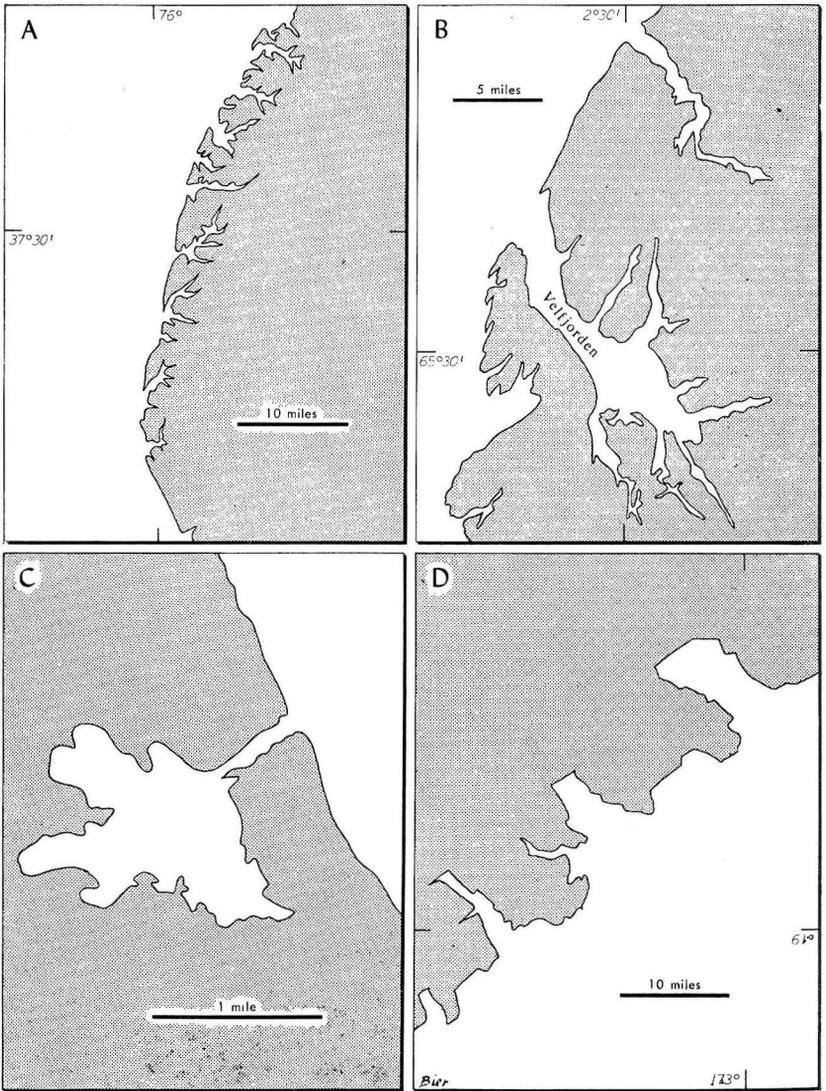


Fig. 1. Bay types: A—Cone shaped bays on the eastern shore of Chesapeake Bay. B—Elongate bays on the coast of Norway. C—Pouch-shaped bay on the northeast coast of Curacao. D—Rectangular bays on the Siberian coast.

coasts are flat or steep. A steep coast is one where the slope of the land above sea level is steeper than that of the strand. If the slope of the land is less than that of the strand the coast is classified as flat. Flat and steep coasts are not only distinguished by their form but also by their composition. Six major types of coast are recognized on the basis of their appearance—smooth coasts, either flat or steep; and embayed and lobed coasts either flat or steep. The character of embayed shores is determined by the nature and origin of the bays. Additional major coastal types are distinguished by rock type and structure.

There are several practical difficulties in using the descriptive aspects of Penck's system. It provides no quantitative boundaries for distinguishing between smooth and embayed coasts. The distinction between steep and flat coasts may also be difficult to make in some cases. The slope of the strand, which is critical in making the distinction between steep and flat coasts, not infrequently varies from place to place quite independently from the above sea slope of the land. Consequently, with changing strand gradient, coasts with the same slope could be flat in some circumstances or steep in others. Furthermore, strands frequently have curved slopes or profiles. Under these circumstances decisions whether a coast is steep or flat can scarcely be consistently definitive.

To circumvent these difficulties, and to keep entirely within a descriptive framework, the classification proposed here uses only two easily recognized shore characteristics to establish the main types of shores—the vertical shore profile (cliffed or non-cliffed), and the shore outline (regular or irregular).

All shore zones are first recognized as either cliffed or non-cliffed. Cliff is defined as an abrupt, local increase of terrain slope forming a steep rock face at or near the shore. (In some instances the cliff may be separated from the waters edge by a wide beach or strand flat.) A shore is considered cliffed if the cliff is more than five feet high and is an enduring feature.

The cliffed and non-cliffed classes can each be further classified according to their horizontal configuration—they are either regular or irregular in outline. In the case of irregular cliffed shores the cliffing is confined to headlands between bays. Regular shores are those with generally smooth outlines, although in detail they may have small irregularities or crenate-shaped bays that are less deep (inland penetration) than wide and are open to the sea. Irregular shores are those having numerous bays of varying size and shape that are deeper than wide and are generally sheltered from the sea. At present the dividing line between regular and irregular shores has not been established firmly enough for objective application. It is evident, however, that the boundary between the two types must be related to the size of the estuaries or bays. Inspection of the coastal charts of northwest Spain, southeast Ireland, south China and the eastern United States indicates the following *tentative* boundary: if, for each unit of bay depth (inland penetration) there are at least five units of unembayed shore between bays, the shore belongs to the regular class—with less than five units of shore between bays and shore belongs to the irregular class.

The regular and irregular classes are broad types that can be subdivided to recognize local conditions. The regular shore type may include crenate shores, smooth, nearly straight shores, and lagoon shores with

association with both the cliffed and non-cliffed shores though lagoons barrier islands of sand or coral. All of the regular subtypes can be found in occur only very rarely with the cliffed class. The types of irregular shore are identified by the shape and dimensions of the bays in a given area. Some of the more common bay types are: long, relatively narrow, cone-shaped bays (sometimes with a winding pattern and branching tributaries); narrow, extended estuaries, frequently with many branches which may be called elongate bays; pouch-shaped bays; and rectangular bays (Figure 1). All bay types are common to both irregular cliffed and irregular non-cliffed shores. Not infrequently the bays occur on non-cliffed shores in conjunction with barrier islands and so form composite lagoon shores.

I. Cliffed shores		II. Non-cliffed shores	
A. Regular	B. Irregular	A. Regular	B. Irregular
1. Smooth	1. Cone-shaped bay	1. Smooth	1. Cone-shaped bay
2. Crenate (or scalloped)	2. Pouch-shaped bay	2. Crenate (or scalloped)	2. Pouch-shaped bay
3. Lagoon (rare)	3. Rectangular bay	3. Lagoon	3. Rectangular bay
	4. Elongate bay		4. Elongate bay
	5. Composite lagoon (rare)		5. Composite lagoon

Table 1. Outline of classification of shore lines.

The system can be applied with facility both in the field and on maps and charts. The classification is flexible since it can be expanded to accommodate additional information. For example, once a shore has been identified as to a specific subtype it can be further classed according to the rock type exposed in the cliff, the nature and composition of the beach, the slope of the near shore bottom and so on.

The classification has been used with apparent success in the field in a mapping assessment of the shore qualities of the coast of Tanganyika between Dar es Salaam and Tanga (an alternating cliffed and non-cliffed, regular, lagoon shore). Using a combination of observation and maps and charts the system has also been tested, again with apparent success, on the coasts of California between Davenport and the Pajaro Valley (cliffed, regular shore; Davenport to Santa Cruz: subtype crenate, Santa Cruz to the Pajaro Valley: subtype smooth), and northeast Venezuela (La Guaira to Cabo Codera, cliffed, regular, crenate shore). The system appears to be a satisfactory means of describing and classifying shores. Further testing will bring about additions and modifications to adjust the classification to additional shore forms or combination of forms that may subsequently be revealed.

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