

agreements with a German firm and an American firm that contradict each other. In spite of Yemen's claim to all the Kamaran Islands, a British company is now exploring there under the terms of a British concession. Exploration concessions have been granted to the international Iraq Oil Company for both Aden Protectorates, but the Sultan of Mahra in the Eastern Protectorate, whose territory adjoins Oman, has granted a conflicting concession to an American company. According to Mr. B. Orchard Lisle (*The Oil Forum*, December, 1953, p. 448) the Iraq Oil Company concession does not apply in the Wadi Beihan area, where an estimated five thousand square miles, containing several oil seepages, has not yet been assigned to any oil company.

No drilling has been done in any of these concession areas. Because of the Buraimi dispute, drilling west of the oasis has been suspended. However, south of Buraimi in territory definitely belonging to the Sultan of Muscat and Oman two concessionaires are now drilling actively: an American concessionaire in Dhofar (a province of the sultanate) has drilled a first well (dry) about 90 miles inland from Salala and additional wells 80 miles farther east (oil discovered); and the Iraq Oil Company has drilled a well (dry) near Hafuf, about 200 miles from the Arabian Sea. This drilling area could have been supplied most conveniently from the north through Trucial Oman and Buraimi, but because of the boundary dispute this route was not used. Instead, supplies were landed at Duqm on the Arabian Sea and brought inland over a new and difficult road.

No reports on quantities of oil discovered are available. Despite the continuing Middle East crisis, development is proceeding in the sultanate, and additional investments are being made. By way of the Cape of Good Hope these concession territories are closer to major areas of oil consumption in Europe and North America, and are farther from the Soviet Union, than any other Middle East oil fields. The present situation may therefore encourage their development.—ALEXANDER MELAMID

PHYSICAL GEOGRAPHY

COASTAL FOGS AND CLOUDS. Boundaries between geographic regions offer opportunity for study of the exchange of regional products; boundaries between climatic regions that differ in heat balance offer opportunity for study of the exchange of heat and moisture. The well-known differences in the thermal characteristics of land and water result in boundaries along coast lines so sharp as to be virtual discontinuities, across which there is rapid movement of contrasting air masses. When one region is invaded by air from the other, it experiences an immediate change in weather; when invasions are repeated, the indigenous climate is replaced by an imported one. On the land side this trial of strength between local and alien (or advective) influences is often visible as fog or as low stratus cloud ("high fog"). Recent investigations in three parts of the world have revealed relations of these fogs to other elements in the physical geography of the coastal lands—upper-air circulation, mountains, forests, and the pattern of local climates. These relations have been subjected to a comprehensive examination by Clyde Perry Patton (*Climatology of Summer Fogs in the San Francisco Bay Area, Univ. of California Publ. in Geogr.*, Vol. 10, No. 3, Berkeley and Los Angeles, 1956) in the San Francisco Bay Area, where parallel coast ranges break sufficiently to allow marine air, channeled into streamlines, to penetrate over inland water into a region of greatly differing heat balance. The cold water off the California coast produces a body of air so different from the air

mass formed over the adjacent land that its incursion across the coast line is almost dramatic in intensity. Dynamic subsidence in the North Pacific Anticyclone results in a low-level inversion, which, strengthened by cooling from below, concentrates the sea-land conflict into a shallow layer. As cold air of the marine part of this layer flows inland through gaps in the coast ranges, its streamlines define a well-marked pattern of temperature and humidity; regional differentiation of climate becomes expressed in two steep gradients, one vertical through the inversion, the other extending inland and displaying increasing temperature as well as the decreasing delay of the annual maximum mapped by Leighly (John Leighly: *The Extremes of the Annual Temperature March, With Particular Reference to California*, *Univ. of California Pubs. in Geogr.*, Vol. 6, No. 6, 1938).

The inversion and associated stratus follow a different regime from that which Neiburger describes for Southern California (Morris Neiburger: *Temperature Changes during Formation and Dissipation of West Coast Stratus*, *Journ. of Meteorol.*, Vol. 1, 1944, pp. 29-41), and Patton feels that Byers' explanation of stratus formation (H. R. Byers: *Summer Sea Fogs of the Central California Coast*, *Univ. of California Pubs. in Geogr.*, Vol. 3, No. 5, 1930) is applicable. Fog formed in the cold air over the sea lifts into low stratus between 500 and 2000 feet in elevation as it flows coastward, penetrating farthest by the end of the night and dissipating during the next day. Maps of stratus frequency show patterns at given hours, and isochrone maps show variation through the day; both series display effects of barriers that confine the streamlines of cloudy air flow. Maximum stratus penetration is about 80 miles; marine advection is felt much farther.

The low air temperature (San Francisco is about 30° F. colder than inland points untouched by either stratus or advection) results from two processes: shading by the stratus deck, and cold advection. To separate their effects, Patton correlates daily maximum air temperature with a cloudiness index and temperature change, after stratifying the data by month and by direction of air flow, in order to compute the equilibrium daily maximum temperature without stratus effect. At San Francisco during the summer this figure averages 4.5° higher than the observed daily maximum; the reduction is assigned to presence of stratus, which thus is of minor importance as compared with the cooling produced by advection of marine air.

Patton's synoptic-geographic approach is supplemented by a well-organized study by the Institute of Low Temperature Science of Hokkaido University (T. Hori, edit.: *Studies on Fogs in Relation to Fog-Preventing Forest* [Sapporo, 1953]), in a region where cutting of coastal forests coincided with an increasing fog problem for inland agriculture. Eighteen men contribute 25 papers, of which 11 deal with theory and observation of the mechanisms that cause fog to dissipate. Katsumi Imahori evaluates three processes: evaporation, settling due to gravity, and downward diffusion in turbulent eddies that deposit droplets on ground or vegetation. He concludes that diffusion is the most important. A fog 200 meters deep, depleted only by gravity, would penetrate 80 kilometers, but gravity and diffusion together dissipate it within 17 kilometers. Heating of the air is significant mainly as it destroys the inversion that bounds the foggy layer, which then mixes with dry air above. Hirobumi Ôura, from measurements of upward and downward fluxes of droplets, describes how the rough forest top increases turbulent diffusion to cause deposition of water at a rate of 0.5 millimeter an hour. Filtering by the forest front is minor; no more water is caught by the front of a forest 10 meters high

than is deposited on a 30-meter strip of its canopy. Zyungo Yosida and Daisuke Kuroiwa measured the drag of wind on the canopy as two or three times that on grass; since drag produces turbulence, the deposit of fog droplets is correspondingly larger on forest cover.

The term "fog precipitation" is more appropriate to this downward diffusion of droplets over a wide area than to the screening action of vertical barriers, but both processes occur where sea fog invades lowlands or where a stratus deck is intersected by mountains. In the Berkeley Hills of California, for example, water is deposited on grass or intercepted by isolated trees. This intercepted fog drip has been measured in various ways; J. F. Nagel (Fog Precipitation on Table Mountain, *Quart. Journ. Royal Meteorol. Soc.*, Vol. 82, 1956, pp. 452-460) developed a cylindrical wire-mesh screen, with vertical cross-sectional area equal to that of the rain gauge opening over which it is set. This fog catcher registered 677 millimeters of water during the two summer months of least rainfall (117 millimeters) and caught fog drip on 212 days of the year. The average rate of drip, 3.75 millimeters an hour, was double the average rate of rainfall. Nagel did not measure the rate of deposit by diffusion, but his notes on the saturated ground suggest that it is large.

Dynamic climatology defines regions which are vulnerable to oceanic invasion and in which low-level inversions and nonprecipitating clouds are common; physical climatology describes the relations of the resulting fog or stratus to other elements of climate and terrain. Cool air and fog from offshore water dominate these coastal lands, but decreasingly so as the air travels inland; the width of the belt in which land use is significantly affected by these imported conditions depends on the streamline pattern, initial differences between land and sea, warming of the inflowing air, and rate of removal of liquid water from it.

Patton examines the streamline pattern, closely terrain-bound in California, with respect to the way it distributes heat and moisture. This pattern, a resultant of upper-air flow and surface relief, is important wherever advection brings qualities alien to the local landscape and the climate it would create. The Bay Area has an astonishing variety of climates: bright sun and cool air; sunny, hot weather; dark overcast and drizzle; and foggy, windy weather that fosters luxuriant vegetation. All exist within a few miles of one another, according as they are on or off major streamlines.

Characteristics of the earth's surface determine its heat balance and properties of the air overlying it. Patton describes the cold ocean off California; and a heat balance more favorable to agriculture is an objective of the Hokkaido study. In fact, a basic question in regional climatology is whether the local heat balance is stronger than the disturbing effects of advection.

As fog-laden air flows inland, it is warmed, but the fog itself influences the warming by its high reflectivity of sunlight. Long-wave radiation emitted downward from the stratus may in part compensate the region for heat lost by shading, but the regional heat balance is, I believe, affected by stratus more than the reduction in air temperature might suggest. Interception of solar radiation makes the Bay Area effectively cool to man and plants.

Removal of fog droplets from the air was studied in Hokkaido with emphasis on mechanical means, usually preferable to evaporation by artificial heating, inefficient except over tiny areas. In California droplets are removed where stratus crosses hills, by

diffusion and screening; over the valleys they are evaporated and the air warmed above its saturation temperature at the cost of perhaps 50 calories of heat a square centimeter of cloud surface.

Whether the aim is to ameliorate the climate, to add moisture of the inflowing air to local water resources, or to arrive at a better understanding of a region's heterogeneous mixture of local and advective climates, solid research such as these studies of fog inflow and its effect on climate is essential. But most of all, they tell us something about what happens at boundaries between regions of contrasting heat balance.—DAVID H. MILLER

GEOGRAPHICAL NEWS

INTERNATIONAL CARTOGRAPHY COURSE. Twenty-one persons from ten countries attended an international Course on Cartography in Switzerland from March 25 to May 18 (*Geogr. Rev.*, Vol. 47, 1957, p. 426). The first four weeks of the course comprised twenty three-hour morning lectures by Professor Eduard Imhof given in Zurich at the Cartographic Institute of the Federal Institute of Technology (Eidgenössische Technische Hochschule). Simultaneous translation into English and French was available. All lectures were profusely illustrated with diagrams, graphs, and tables and with slides. For better visual comparison three separate projectors were used. Most afternoons were devoted to practical exercises and demonstrations, at which Professor Imhof was aided by several capable assistants. The lectures covered the art of cartographic representation thoroughly: 1, position, purpose, and trends of cartography; 2, terrain representation; 3 and 4, contour and fathom lines; 5 and 6, shade tints, slope shading, and illumination; 7, hachure lines; 8, representation of rock cliffs; 9 and 10, color tones, sense and possibilities of color application; 11, representation of landscape; 12, geomorphological view of the terrain; 13, cultural features and vegetation cover shown on topographical maps; 14-20, thematic maps: (14) definition, topics, and general rules of elaboration; (15) locational data and their representation; (16) distributions and their presentation; (17) linear occurrences and their presentation; (18) mosaic configuration of areas; (19) isolines and flow lines; (20) various topics. Unfortunately, a thorough evaluation of these excellent lectures is impossible in this brief report.

Of special interest were Professor Imhof's detailed demonstrations of the methods used in the preparation of shaded relief. With his scientifically drawn shading he has been able to produce maps with beautiful simulated three-dimensional relief, which are paragons in their class. For example, always an inspiration to behold and study was his large shaded-relief mural "Die Landschaft um den Walensee" on the wall of the conference hall of the Cartographic Institute. This mural map has been reproduced as a full-page black-and-white illustration for his "Aufgaben und Methoden der theoretischen Kartographie" in *Petermanns Geographische Mitteilungen* (Vol. 100, 1956, pp. 165-171). The article and his book, "Gelände und Karte" (Erlenbach-Zurich, 1950), contain the main substance of the course. In Switzerland, only the French version of the book (*Terrain et carte* [Erlenbach-Zurich, 1951]) is available; the German edition is exhausted. Considerable interest has been shown in the possibility of an English translation, but the reproduction of the hundreds of illustrations (343 in black and white; 34 in color) may well make the cost of an English edition prohibitive.

One afternoon was devoted to a visit to the Art. Institut Orell Füssli AG., where the