~~RESTRICTED~~

CONFIDENTIAL

SPECIAL REPORT

STRATEGIC ENGINEERING STUDY NO. 138

FUKIEN REGION (CHINA)
(SUMMARY)

TERRAIN INTELLIGENCE

Prepared by

GEOLOGICAL SURVEY, U.S. DEPARTMENT OF THE INTERIOR

Under direction of

CHIEF OF ENGINEERS, U.S. ARMY

COPY 450

MILITARY INTELLIGENCE DIVISION
OFFICE, CHIEF OF ENGINEERS
U.S. ARMY

DECEMBER, 1944

ARMY MAP SERVICE, U.S. ARMY, WASHINGTON, D.C. 201553
1-45 1944

~~CONFIDENTIAL~~

~~CONFIDENTIAL~~

CONFIDENTIAL

SPECIAL REPORT

STRATEGIC ENGINEERING STUDY NO. 138

FUKIEN REGION (CHINA)
(SUMMARY)

TERRAIN INTELLIGENCE

Prepared by
SECTION OF MILITARY GEOLOGY
GEOLOGICAL SURVEY, U.S. DEPARTMENT OF THE INTERIOR
Under direction of
CHIEF OF ENGINEERS, U. S. ARMY

STRATEGIC INTELLIGENCE BRANCH
MILITARY INTELLIGENCE DIVISION
OFFICE, CHIEF OF ENGINEERS
U. S. ARMY

DECEMBER, 1944

Requests for copies of this report
should be addressed to...
CHIEF, MILITARY INTELLIGENCE DIVISION
OFFICE OF THE CHIEF OF ENGINEERS
Washington, D.C.

ARMY MAP SERVICE, U. S. ARMY, WASHINGTON, D. C., 201553
I-45 1944

TABLE OF CONTENTS

SUMMARY OF TERRAIN SITUATION

FUKIEN REGION (CHINA)

CONFIDENTIAL

EXPLANATION

- Mud flats (Partly bare at low tide; includes some sand banks)
- Sand beaches and coastal sand dunes
- Salt pans
- Lakes and ponds
- Rivers and streams (Includes main canals in flat-lying alluvial areas)
- Drainage ditches and minor canals (In flat-lying alluvial areas; main outlines from source maps, detailed features schematic)
- Relief features
- ▲ 3379 Spot heights (Altitudes in feet above sea level)
- Cities and towns (Only more important shown)
- Railroads (Now in part abandoned or destroyed)
- Province boundaries

0 10 20 30 40 50 Miles

0 10 20 30 40 50 60 70 80 Kilometers

Terrain diagram drawn on map base A.M.S. 5301, 1:1,000,000, sheets NG 50 and NG 51. Geographical outlines and terrain features completely revised and details added from A.M.S. 581, 1:250,000; Chinese General Staff Land Survey, 1:100,000; Ting Atlas, 1:2,000,000; Hydrographic Office and Admiralty charts; various geological maps; and other sources. Altitudes in feet above sea level. The appearance of perspective is obtained by shifting all relief features northward by 1/10 inch for each 3,000 feet. Distances on map can therefore be scaled off only between points of equal altitude. Altitudes and locations of points on diagram are believed to have proper relation to points in surrounding areas, but true relations to sea level and to latitude and longitude are uncertain.

Roman numerals and heavy lines refer to areas discussed in accompanying table.

I. Feng-huang Islands
II. Chekiang Coast
III. Fukien Coast
IV. Chekiang-Fukien Mountains
V. Han Chiang Drainage Basin
VI. Lung-shih Range
VII. East Kiangsi Hills and Mountains
VIII. Kiangsi Lowland

PREPARED BY U. S. GEOLOGICAL SURVEY
FOR
CHIEF OF ENGINEERS, U. S. ARMY

FUKIEN REGION (CHINA) — SUMMARY OF TERRAIN SITUATION

I. Introduction

A. Population of the Fukien region is estimated from census figures (1928-1935) for Fukien, Kiangsi, Chekiang, and Kwangtung Provinces at 15 to 20 million. At the coast are several important cities: Min-hou (390,363 inhabitants), Ssu-ming (219,974), P'u-t'ien, Chin-chiang, and Lung-ch'i. Numerous towns and villages are scattered throughout the region.

B. Climate is warm humid temperate in the north and humid subtropical in the south. Typhoons occur in late summer, especially in the area from Min-hou north. Precipitation averages 40 to 80 inches per year; it is generally highest in the interior. Mean monthly temperature range is 55° to 85° F at coast; greater range inland.

II. Topography and Movement

A. Fukien region is chiefly mountainous and hilly (Map Units I-VII). Flat lands are restricted mainly to discontinuous belts on the coast (Map Units II,III) and in river valleys (Map Units IV,V, VII) Lowlands are extensive only in northwestern part of region (Map Unit VIII). About 15 to 20% of this region is under cultivation, largely in rice.

B. Vehicular movement is limited generally to existing routes. Cross-country movement in the flat lands and low hills is generally easy for foot troops, but is considerably restricted for vehicles by rice fields; in mountains, difficult for foot troops and probably impossible for vehicles.

III. Road Construction Problems

A. Existing Highways and Railways: Fair road net, restricted largely to coast and lowland areas in interior. Much of mountainous country is without roads. Numerous trails in all parts of region. Only operating railway line crosses northwestern part of region.

B. Ease of Constructing Additional Roads: Best routes probably used by existing roads or trails, many of which need improvement and repair. Extensive mountain country offers difficult construction problems.

C. Major Construction Problems: In flat lands, drainage and bridging of streams and canals are main problems. In hilly areas, much grading is necessary. In mountains, long side-hill cuts require extensive blasting of bedrock.

IV. Airdrome Construction Problems

A. Possible Airdrome Sites: Few good sites are available. Sites are restricted to small coastal and valley flats; most numerous along coast and in northwest part of region. Steep slopes of adjacent hills commonly limit approaches.

B. Major Construction Problems: Many flat areas near coast have poor natural drainage and heavy clay soil, which is difficult to stabilize. Considerable grading is required at most sites in small mountain valleys and in areas of low hills. Construction materials are easily accessible at most sites.

V. Construction Materials

A. Sand and Gravel: Abundantly available in most streams in and near upland areas; also locally from narrow beaches fringing mountainous parts of coast.

B. Hard Rock: Generally available in upland areas, except in northwest, where bedrock suitable for construction is present only locally.

C. Timber: Most abundant in mountainous areas. Generally lacking in lowlands and areas near cities and larger towns.

VI. Mineral Fuels

Coal (non-coking bituminous and anthracite) is present in scattered small deposits, worked mainly by non-mechanized methods. The output is insignificant and is consumed locally. The coastal region is supplied in normal times from North China and Formosa.

VII. Water Supply

A. Water supplies plentiful in Fukien Region, except in Feng-huang Is.

B. Existing Supplies: Inhabitants obtain water supplies chiefly from streams and shallow wells. Ssu-ming, Lung-yen, Min-hou, and Nan-p'ing are supplied in part by municipal installations.

C. Potential Supplies: Large water supplies can be obtained from streams and, in lowland areas, from wells. All surface and shallow ground water should be thoroughly treated before use.

Map Unit	Suitability of Terrain for Vehicular Movement			Roads and Railroads		Suitability for Airfield Construction	Water Supply
	Topography	Vegetation	Stream Crossings	Existing Roads and Railroads	Suitability for Road Construction		
I. Feng-huang Islands	▒		▒	▒	▒	▒	▒
II. Chekiang Coast	▒				▒	▒	
III. Fukien Coast	▒			▒	▒		
IV. Chekiang-Fukien Mountains		▒		▒		▒	
V. Han Chiang Drainage Basin	▒	▒				▒	
VI. Lung-shih Range							
VII. East Kiangsi Hills and Mountains	▒			▒	▒	▒	
VIII. Kiangsi Lowland			▒	▒			

Conditions

- Good in most places; fair to poor in others.
- ▒ Fair to poor in most places; good in limited areas.
- ▒ Generally poor.

PREPARED BY U. S. GEOLOGICAL SURVEY
FOR
CHIEF OF ENGINEERS, U. S. ARMY

CHINA
EAST COAST

EXPLANATION

- Outline of shoal water areas (Less than 20 feet deep; only larger areas shown)
- Mud flats (Partly bare at low tide; includes some sand bars)
- Sand beaches and coastal sand dunes
- Salt pans
- Lakes and ponds
- Marshes and swamps
- Rivers and streams (Includes main canals in flat-lying alluvial areas)
- Drainage ditches and minor canals (In flat-lying alluvial areas; main outlines from source maps, detailed features schematic)
- Grand Canal (Yün Ho)
- Dry stream beds and sand washes (In northern part of area)
- Former course of Huang Ho (Before 1852)
- Relief features
- 4186 Spot heights (Altitudes in feet above sea level)
- Cities and towns (Only more important shown)
- Province boundaries

10 0 10 20 30 40 50 MILES

10 0 10 20 30 40 50 60 70 KILOMETERS

Terrain diagram drawn on map base A M S 5301, 1:1,000,000, sheets N F 50, N G 50-51, N H 50-51, and N I 50-51. Geographical outlines and terrain features completely revised and details added from: Chinese General Staff Land Survey, 1:100,000; A M S 1581, 1:250,000; Ting Atlas, 1:2,000,000; Hydrographic Office and Admiralty charts; various geological maps; and other sources.

Altitudes in feet above sea level. The appearance of perspective is obtained by shifting all relief features northward by 1/10 of an inch for each 6,000 feet. Distances on map can therefore be scaled off only between points of equal altitude. Altitudes and locations of points on diagram are believed to have proper relation to points in surrounding areas, but true relation to sea level and to latitude and longitude is uncertain. Recent drainage changes, such as those near Huang Ho in north part of map, are inadequately represented, as they are not shown on available sources.

PREPARED BY U. S. GEOLOGICAL SURVEY
FOR
CHIEF OF ENGINEERS, U. S. ARMY

FUKIEN REGION (CHINA)

INTRODUCTION

This report was prepared by the Geological Survey, United States Department of the Interior, for the Chief of Engineers, U. S. Army, from August to November, 1944. It was prepared in conjunction with reports on adjacent China Coast regions (See Terrain Diagram, opposite page). Similar map units and patterns were used in corresponding maps of adjacent regions. Some units may be distinguished in one region where there are abundant data and grouped as a single unit in others where there is less information. Numbers do not correspond with those used in adjacent regions.

The report is a brief regional description of the terrain features of the Fukien region of southeastern China that are significant in planning military operations. Each of the maps and tables deals with a special set of problems; these include the relationship of terrain to movement, problems of airdrome and road construction, water supply, and nature and location of the principal construction materials and mineral deposits. Information from which interpretations have been made is summarized in maps and tables on geology and soils. Climate is described only in a cursory manner; other intelligence sources should be consulted for detailed information on this subject.

RELIABILITY OF INFORMATION

The Fukien region is an undeveloped and largely inaccessible part of China. Although this report is only a generalized survey, it is probable that, for large parts of the region, little detail could be added by further examination of the available published information. The completeness and reliability of data in the report are rated in grades ranging from good to poor.

An important deficiency in data on the Fukien region is the absence of reliable maps. Excessive differences in location of towns and course of drainage as shown on different maps have necessitated much interpretation in plotting information.

Topographic maps (scale 1:100,000) of the Chinese General Staff Land Survey for the Fukien region are generally inadequate, giving only a rough picture of the terrain features. A geologic map (scale 1:2,000,000) prepared by the Tokyo Geographical Society is the only complete map of its type for the region. Some detailed maps of better quality accompany geologic reports, but cover only part of the region.

PRINCIPAL SOURCES OF INFORMATION

General:

Arnold, J., et al., China, a commercial and industrial handbook: U. S. Dept. Commerce, Trade Promotion Ser. no. 38, 818 pp., 1926.

Behagel, G., Eine Reise in der chinesischen Provinz Fukien: Globus, Bd. 94, pp. 242-252, 265-269, 277-283, 1908.

Buck, J. L., Land utilization in China, pt. 1 (text, 494 pp.), pt. 2 (atlas, 146 pp.), Chicago and Nanking, 1937.

Buxton, L. H. D., China, the land and its people--A human geography, 333 pp., Oxford, 1929.

Cressey, G. B., Asia's lands and peoples, 608 pp., New York, 1944.

----------, The land forms of Chekiang, China: Assoc. Amer. Geog. Ann., vol. 28, pp. 259-276, 1938.

Franck, H. A., Roving through southern China, 649 pp., New York, 1925.

Fuson, C. G., The geography of Kwangtung: Lingnan Sci. Jour., vol. 6, pp. 241-254, 1928.

----------, The new geography of China, 260 pp., Shanghai, 1933.

Hurlbut, F., The Fukienese--A study in human geography, 143 pp., Muncie, 1939.

Thompson, J., Through China with a camera, 284 pp., London, 1898.

Viguers, R. T., Reconstruction of Fukien: China Weekly Rev., vol. 80, pp. 248-249, 1937.

Wegener, G., Das chinesische Reich: Nordasien, Zentral-und Ostasien, Handb. geog. Wiss., pp. 245-434, Potsdam, 1937.

----------, Durch die Provinz Kiang-si: Gesell. Erdkunde, Zeitschr, pp. 124-138, 155-170, 1926.

----------, Im innersten China--Eine Forschungsreise durch die Provinz Kiang-si, 410 pp., Berlin, 1926.

Williams, E. T., The open ports of China: Geog. Rev., vol. 9, pp. 306-334, 1920.

Woodhead, H. G. W. (editor), The China Year Book, 1936, 510 pp., Shanghai, 1936.

General (continued)

China Hand Book, 1937-1943, 876 pp., New York, Chinese Ministry of Information, 1943.

Chinese Year Book, 1938-1939 issue, 754 pp., Chungking, Council of International Affairs, 1939.

Fukien--A study of a province in China: Anti-Cobweb Society, 113 pp., Shanghai, 1925.

Fukien--Arts and industries: Anti-Cobweb Society, 310 pp., Foochow, 1933.

Sailing directions for the coast of China: U. S. Navy, Hydrographic Office, H. O. no. 124, 4th ed., 1943.

Geology and Mineral Resources:

Chan, K., Geology and mineral resources of the Chungjen-Ihuang Area: Geol. Surv. Kiangsi, Bull. no. 4, pp. 71-127 (Chinese), 129-133 (English summary), 1940.

--------, Geology of the Sinkan-Hsiachiang Area: Geol. Surv. Kiangsi, Bull. no. 5, pp. 1-52 (Chinese), 53-56 (English summary), 1940.

--------, On the subdivisions of the redbeds of southeastern China: Geol. Soc. China Bull., vol. 18, pp. 301-324, 1938.

Chan K., and Liu, H. S., Geology of the Kungshui Valley, southern Kiangsi: Geol. Surv. Kiangsi, Bull. no. 2, 63 pp. (Chinese), 1939.

Chen, S., On the marine Triassic of Fukien: Geol. Soc. China Bull., vol. 22, pp. 211-215, 1942.

Hou, T. F., Wang, Y. L., and Chang, C. C., Geological reconnaissance between Lungyen and Amoy, Fukien: Geol. Surv. China, Bull. 25, pp. 1-8 (English summary), 1935.

Hsia, S. Y., Geology and mineral resources of the Fungcheng-Linchuan Area: Geol. Surv. Kiangsi, Bull. no. 4, pp. 37-66 (Chinese), 67-69 (English summary), 1940.

Hsieh, C. Y., and Cheng, Y. C., Geology and mineral deposits of Anchi, Yungchun and Yungtai Districts, Fukien Province: Geol. Surv. China, Bull. 27, pp. 1-30, 1936.

Hsu, K. C., Tungsten deposits of southern Kiangsi, China: Econ. Geology, vol. 38, pp. 431-474, 1943.

Huang, T. K., The Permian formations of southern China: Geol. Surv. China Mem., Ser. A, no. 10, 140 pp., 1932.

Strategic Engineering Study, Mineral resources of China (in preparation), Military Geology Unit, U. S. Geol. Surv.

Kao, P., Coal fields in Kiangsi: Geol. Surv. Kiangsi, Bull. no. 1, pp. 1-19 (Chinese), 1939.

Kao, P., and Hsia, S. Y., Geology of the Fengcheng coal fields: Geol. Surv. Kiangsi, Bull. no. 1, pp. 20-55 (Chinese), 1939.

Kao, P., and Hsu, K. C., Geology of western Kiangsi: Geol. Surv. China Mem., Ser. A, no. 16, pp. 1-60 (Chinese), 61-72 (English summary), 1940.

Lan, F. K., An outline of the stratigraphy of Kwangtung and Kwangsi: Sci. Soc. China Trans., vol. 6, pp. 1-19, 1930.

Lee, J. S., The geology of China, 528 pp., London, 1939.

Lee, J. S., and Chu, S., Note on the Chihsia limestone and its associated formation: Geol. Soc. China Bull., vol. 9, pp. 37-43, 1930.

Li, K. C., and Wang, C. Y., Tungsten: Amer. Chem. Soc., Sci. and Technol. Mono. Ser. no. 94, pp. 20-44, 1943.

Liu, H. S., Geology of the Yungfeng-Chishui Area: Geol. Surv. Kiangsi, Bull. no. 5, pp. 57-89 (Chinese), 91-92 (English summary by K. Chan), 1940.

Liu, H. S., and Wang, C. S., Geology of the Tunghsiang-Chingchi Area: Geol. Surv. Kiangsi, Bull. no. 2, 22 pp. (Chinese), 1939.

Mok, C., and Hu, H. S., Geology of the Chian-Tienho Area: Geol. Surv. Kiangsi, Bull. no. 6, pp. 25-60 (Chinese), 61-72 (English summary), 1941.

Sen-Shing, Y., and Wen-Kwang, Y., Preliminary report on the geology and mineral resources of Han Chiang Region, eastern Kwangtung: Geol. Surv. Kwangtung and Kwangsi, Ann. Rept., vol. 4, pt. 1, pp. 19-27, 1931-1932.

Tan, H. C., The tuff-conglomerate formation in China: Geol. Soc. China Bull., vol. 5, pp. 149-156, 1926.

Tan, H. C., and Wang, S. W., Geological reconnaissance along the projected railway line from Nanchang to Fuchow: Geol. Surv. China, Bull. 14, pp. 1-6 (English summary), 1930.

Tegengren, F. R., The iron ores and iron industry of China: Geol. Surv. China Mem., Ser. A, no. 2, pt. 2, 1924.

Geology and Mineral Resources: (continued)

Wang, H. S., and Li, C. Y., Geological reconnaissance along the Nanking-Nanping section of the projected railway line from Nanking to Canton: Geol. Surv. China, Bull. 14, pp. 7-11 (English summary), 1930.

Wong, W. H., Crustal movements and igneous activities in eastern China since Mesozoic time: Geol. Soc. China Bull., vol. 6, pp. 9-36, 1927.

----------, The mineral resources of China: Geol. Surv. China Mem., Ser. B, no. 1, 1919. (Chinese text only)

Yen, K. Y., The gypsum deposits of Taihohsien: Geol. Surv. Kiangsi, Bull. no. 5, pp. 109-115 (Chinese), 117 (English summary by K. Chan), 1940.

Yih, L. F., Li, H., and Chang, K., The alumstone of Pingyang, Chekiang: Acad. Sin., Nat. Res. Council China, Inst. Geol., Misc. Publ. 10, pp. 1-49, 1930.

Young, C. C., A review of early Tertiary formations of China: Geol. Soc. China Bull., vol. 13, pp. 469-503, 1934.

Soils:

Thorp, J., Geography of the soils of China: Nat. Geol. Surv. China, 552 pp., 1936.

Tschau, C. Y., and Shen, T. P., Soils of Yungan and Sanyuan Districts, Fukien: Geol. and Soil Survey, Fukien, Soil Rept. no. 4, 1943.

Wu, P. C., Chu, S. M., and Fu, H. D., Soils of the Taiho Area: Geol. Surv. Kiangsi, Bull. no. 6, pp. 157-186 (Chinese), 187-188 (English summary), 1941.

Vegetation:

Hinman, G. W., A forest project in Fukien: China Weekly Rev., vol. 75, pp. 316-317, 1936.

Hu, H. H., A preliminary survey of the forest flora of southeastern China: Biol. Lab. Contr., Sci. Soc. China, vol. 2, no. 5, 20 pp., 1927.

Metcalf, F. P., Flora of Fukien and floristic notes on southeastern China (Fasc. 1), 82 pp , Canton, Lingnan Univ., 1942.

Water Supply and Climate (See also titles under General):

Fang, F. A., Public works in Amoy: Far Eastern Review, vol. 27, p. 216, 1931.

Gherzi, E., Etude sur la pluie en Chine (1873-1925), Shanghai, Observatoire de Zi-ka-wei, 1928.

Hurlbut, F., The climate of Fukien Province: Fukien Christian Univ., Nat. Hist. Soc. Proc., vol. 3, pp. 39-45, 1930.

Koo, T. Y., Preliminary report on investigation of Foochow water supply: Assoc. Chin. and Amer. Eng. Jour., vol. 17, p. 139, 1936.

O'Rourke, C. E., Reply to "Sanitation in China as noted by an American engineer": Engineering News-Record, vol. 105, p. 185, 1930.

Wang, T. H., The analysis and study of Min River water: Sci. Soc. China Trans., vol. 7, pp. 37-46, 1934.

Irrigation in Fukien: Far Eastern Review, vol. 21, pp. 222-223, 1925.

Waterworks at Amoy: Engineering, vol. 120, p. 137, 1925.

See also U. S. Army Air Forces climate reports listed under Intelligence Reports.

Intelligence Reports:

British Admiralty, China, C. B. 1840, Intelligence report.

Commander-in-Chief Pacific Area-Commander-in-Chief Pacific Ocean Areas, China coast--Southeastern section from Shanghai to Swatow, CINCPAC-CINCPOA Bull. no. 128-44, August 25, 1944.

U.S. Army Air Forces, Headquarters, Weather Information Branch:
Climate of Amoy (China), General Climatic Information Guide no. 106, January 1944
Climate of Minhow (China), General Climatic Information Guide no. 144, June, 1944.

U. S. Army, Engineer Research Office, China--South of the Yangtze E. R. O. Special Report no. 24, 1943.

U. S. Army, Office Asst. Chief of Air Staff, Intelligence:
Photo Intelligence Report no. 466, March 22, 1944.
Provisional Airfield List--China, Enemy Airfield Information Report no. 2, July 8, 1944.

Maps:

Army Map Service, China Proper, S. E., 1:250,000, Series L581, 3rd edition (AMS L 1944:

Sheet L6	Yung-feng	Sheet 60	Min-hou (Foochow)
47	Nan-ch'eng	61	Hsia-p'u (Funing)
48	Kuang-tse	65	Hui-ch'ang
49	Chien-ou (Kienning)	66	Ch'ang-t'ing (Tingchow)
50	Shou-ning	67	Lung-yen
51	P'ing-yang	68	Hsien-yu
52	Huang-ta-ao	69	P'u-t'ien (Hinghwa)
56	Hsing-kuo	73	Hsing-ning
57	Shih-ch'eng	74	Mei-hsien
58	Sha-hsien	75	Lung-ch'i
59	Nan-p'ing (Yenping)	76	Hsia-men (Amoy)

Army Map Service, Eastern Asia, 1:1,000,000, Series 5301, 1st edition (AMS 1), 1944:
Sheet NG-50 Min-hou (Foochow)
NG-51 Taihoku

Chinese General Staff Land Survey Maps, 1:100,000, 1931-1935.

Tokyo Geographical Society (editors), Geological atlas of eastern Asia, scale 1:200,000, Sheet 15, Taiwan, 1929.

U. S. Navy, Hydrographic Office Charts:

3180	Wenchow Bay to Kueshan Is.
3179	Tungyung to Wenchow Bay
1761	Ockseu Is. to Tungyung
3176	Formosa Strait and Taiwan (Formosa)
3177	The Brothers to Ockseu Is.
2546	Wu Kiang or Wenchow River and Approaches
3208	Namkwan Harbor
2556	Approaches to Samsa Inlet (Santu Ao)
2557	Samsa Inlet (Southern Approaches)
3206	The Narrows of Haitan Strait
3204	Haitan Strait
3205	Red Yit and Rugged Island
2519	Chuanchow Harbor
1322	Approaches to Amoy
1676	Quemoy Harbor
1285	Amoy Harbor
2157	Amoy Inner Harbor
3158	Plans on the South Coast of China

Prepared by U. S. Geological Survey
for Chief of Engineers, U. S. Army

EXPLANATION

- Mud flats (Partly bare at low tide; includes some sand banks)
- Sand beaches and coastal sand dunes
- Salt pans
- Lakes and ponds
- Rivers and streams (Includes main canals in flat-lying alluvial areas)
- Drainage ditches and minor canals (In flat-lying alluvial areas; main outlines from source maps, detailed features schematic)
- Relief features
- ▲ 3379 Spot heights (Altitudes in feet above sea level)
- Cities and towns (Only more important shown)
- Railroads (Now in part abandoned or destroyed)
- Province boundaries

0 10 20 30 40 50 Miles

0 10 20 30 40 50 60 70 80 Kilometers

Terrain diagram drawn on map base A M S 5301, 1:1,000,000, sheets NG 50 and NG 51. Geographical outlines and terrain features completely revised and details added from A M S L 581, 1:250,000; Chinese General Staff Land Survey, 1:100,000; Ting Atlas, 1:2,000,000; Hydrographic Office and Admiralty charts; various geological maps; and other sources. Altitudes in feet above sea level. The appearance of perspective is obtained by shifting all relief features northward by 1/10 inch for each 3,000 feet. Distances on map can therefore be scaled off only between points of equal altitude. Altitudes and locations of points on diagram are believed to have proper relation to points in surrounding areas, but true relations to sea level and to latitude and longitude are uncertain.

PREPARED BY U. S. GEOLOGICAL SURVEY
FOR
CHIEF OF ENGINEERS, U. S. ARMY

TERRAIN DESCRIPTION

FUKIEN REGION (CHINA)

CONVERSION GRAPH

Meters: 3,000 | 2,500 | 2,000 | 1,500 | 1,000 | 500 | 0

Feet: 10,000 | 9,000 | 8,000 | 7,000 | 6,000 | 5,000 | 4,000 | 3,000 | 2,000 | 1,000 | 0

EXPLANATION

- Main surfaced all-weather roads.
- Other roads; mostly unsurfaced, many poor in wet weather.
- Road destroyed in many places.
- Road probably destroyed in many places.
- Railroad.
- Railroad destroyed.

GLOSSARY

Ao ..... bay
Ch'i ..... stream
Chiang ..... river
Feng ..... mountain
Hai-kou ..... strait
Ho ..... river
Hsia ..... strait
Hsü ..... island
Lieh-tao ..... island group
Ling ..... mountain
Shan ..... island, mountain
Shui ..... river
Tao ..... island
Wan ..... bay

EXPLANATION

Flat Areas: Mud flats and sand beaches along coast; river flood plains and terraces in interior. In Areas VII and VIII pattern includes some low hilly belts with relief less than 300 feet.

Hills: Generally rolling, locally rugged country with relief 1,000 feet or less.

Mountains: Rugged country with relief generally between 1,000 and 3,000 feet.

EXPLANATION

Roman numerals and heavy lines refer to Map Units discussed in accompanying text.

I. Feng-huang Islands.
II. Chekiang Coast
III. Fukien Coast.
IV. Chekiang-Fukien Mountains.
V. Han Chiang Drainage Basin.
VI. Lung-shih Range
VII. East Kiangsi Hills and Mountains.
VIII. Kiangsi Lowland.

Reliability

- Good
- Fair
- Poor

Scale 1:1,000.000

10 5 0 10 20 30 40 50 60 70 80 90 100 Miles

10 5 0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 Kilometers

HEIGHTS IN METERS

Base adapted by A.M.S. and U.S.G.S. from A.M.S. 5301, 1:1,000,000, Sheets NG 50 and NG 51, 1944.

PREPARED BY U. S. GEOLOGICAL SURVEY FOR CHIEF OF ENGINEERS, U. S. ARMY

FUKIEN REGION (CHINA)

TERRAIN DESCRIPTION

Reliability: Good for Map Units I, II, III, VII, and VIII; fair for Units IV, V, and VI.
Summary report; additional information available for more detailed studies.

Map Unit	Topography	Drainage	Settlements and Land Use[a]	Communications[a]
I FENG-HUANG ISLANDS	Bare rugged rocky islands with irregularly embayed coasts; two largest are each about 6 miles long and 3 to 4 miles across. Hills and ridges sharp-crested or pinnacled. Relief between 750 and 1,400 feet on larger islands; 500 feet or less on islands less than 1/2 mile across.	Short perennial and intermittent streams flow in narrow V-shaped valleys radiating from peaks. Gradients steep; discharge small; streams not navigable.	Settlements generally confined to islands greater than a mile in diameter. On larger islands, fishing villages at heads of embayments; a few small farming communities in interior of largest islands.	Communication along coast and between islands by fishing boats. No road net; trails lead inland from coasts of larger islands.
II CHEKIANG COAST	Coastal belt 25 miles wide; irregular shoreline indented at intervals of 15 to 30 miles by narrow inlets along larger streams. Low flat areas as much as 6 miles wide along streams and northern half of coast. Interstream areas hilly and mountainous; largely deforested. Relief between 500 and 1,500 feet in hilly and mountainous areas.	Drained by eastward-flowing streams with headwater areas only about 60 miles west of coast; lower courses are sluggish meandering tidal estuaries. Several mud flats in lower course of Ou-Chiang[b]; largest is Ling-k'un Island. Flat areas poorly drained; rainfall ponded in rice fields or diverted into canals. Hilly and mountainous areas between larger rivers well drained by network of short intermittent and perennial streams flowing in narrow valleys.	Minor ports of Jui-an (pop.20,000) and Ku-ao-t'ou (pop.15,000 to 20,000) situated near mouths of embayments. Numerous small fishing villages along coast; small agricultural settlements scattered through densely populated lowlands. Lowlands intensively cultivated; irrigated; rice is principal crop. Tea grown on hill slopes.	No road net; main route parallels coast 6 to 30 miles inland. Larger eastward-flowing streams navigable for launches and junks. Integrated canal system in lowlands permits travel by small boats.
III FUKIEN COAST	Rugged coastal belt between 5 and 45 miles wide. Predominantly hilly or mountainous with ridges aligned prevailingly N to NE; uplands largely deforested, covered with grass and scrubby vegetation. Level ground restricted to floodplains of larger streams, discontinuous coastal strips generally less than one mile across, and to a few lowland belts crossing peninsulas and offshore islands in a NE direction. Coast deeply indented; bold promontories alternate with irregularly branching bays. Several hilly islands and numerous rocky islets offshore. Hilly and mountainous headlands cliffed. Mud flats border estuarine areas. A few small sand beaches in embayments along larger promontories and islands. Relief generally between 500 and 3,000 feet in hilly and mountainous areas.	Area includes lower reaches of Chiao-Ch'i, Min-Chiang, Chiu-lung Chiang and other large perennial streams draining Fukien hinterland. Rivers enter sea along channels flanked by tidal mudflats; no extensive delta flats above high-tide level. Hilly and mountainous areas between major streams drained by intricate network of perennial and intermittent streams. Run-off rapid, accelerated by widespread deforestation along coast and to the west. River in high stage June to July; low stage November to January. Occasional floods from late February through summer.	Area south of Min-Chiang is one of most thickly populated in China. Larger cities are ports near mouths of larger streams (Lung-ch'i, Chin-chiang, P'u-t'ien, and Min-hou) or on islands fronting their estuaries (Ssu-ming, San-tu). Shores of innumerable small embayments are sites for fishing villages. Numerous small agricultural settlements throughout lowland and hilly areas. Ssu-ming (better known as Amoy) is center for trade in sugarcane and tobacco. Min-hou (better known as Foochow) is terminus for river boats operating in the Min-Chiang drainage; also a port of call for ocean-going steamers. San-tu is a center for tea and chinaware trade. Area largely deforested. About one-fifth of land suitable for cultivation; of this about 75% is irrigated, and 70% to 90% planted in rice. Tea, corn, soy beans, and sweet potatoes cultivated on terraced hillsides.	Water routes used more extensively than overland routes for communication between many coastal towns. Coastwise communication by boat favored by numerous inlets affording anchorage and refuge from storms. Lower reaches of larger streams navigable by small craft; heavy river traffic by motor launches and junks. Transportation by ferry between Amoy Island and mainland. Road net largely destroyed; was extensive between the Nan Ch'i and Mu-lan Ch'i. Main coastal road connects Lung-ch'i and Min-hou; network of secondary roads and porter trails in hilly belts between main road and the coast. Long stretches of mountainous country between Min-hou and the northern limit of area and from Lung-ch'i to the southern boundary of map area virtually without roads except in a few minor corridors flanked by mountains.
IV CHEKIANG-FUKIEN MOUNTAINS	Rugged mountainous country with ridges and valleys aligned predominantly NE. Regionally inclined toward east and, except for small border areas, drained by eastward-flowing trunk streams crossing the topographic grain at right angles. Discontinuous narrow flat stretches along streams. Small areas of hilly land mostly in NE-trending belts. Mountains largely deforested around settlements and along lines of river or overland transportation. Relief generally greater than 1,000 feet; locally as much as 3,500 feet in higher mountains.	Area well drained; lakes few and small, confined to valleys. With exception of small areas at northwest corner of region, area drains east through large rivers. More than 2/3 of area drains into Min-Chiang. Tributaries have prevailing NE or SW courses, entering trunk streams roughly at right angles. Streams generally swift with gravelly and sandy bottoms; bars and small flats common near bends. Eastward-flowing streams generally in narrow gorges with rapids in gaps through ridges; floodplains limited to discontinuous strips, generally not more than a few hundred feet across. NE- and SW-flowing streams have broader valleys and more even gradients; stream flats discontinuous but more extensive than along eastward-flowing streams. Occasional floods in spring and summer; destructive effects accentuated by widespread deforestation.	Sparsely populated; settlements largely confined to farming communities on flats and low hilly belts along streams. Chien-ou (pop.70,000) and Shao-wu (pop.15,000) are centers for agricultural trade. Yung-an is provisional capital of Fukien; Chien-yang is traffic center for routes into Chekiang and Kiangsi Provinces. Nan-p'ing is port for river traffic to Foochow. Roughly 10% of area in cultivation; arable land includes all flats and gentle hill slopes as well as some artificially terraced mountain valleys. Irrigated land mostly devoted to rice; tea on terraced hills. Considerable timber reserves in upper reaches of Min-Chiang drainage.	Road net not extensive; stream crossings numerous; maintenance a constant problem in most areas. NW routes across topographic grain characterized by local stretches with steep gradients. NE routes, following topographic grain, have gentler gradients. All routes must follow streams in part; hence subject to temporary disruption during floods when bridges are out and ferries inoperative. Network of foot trails in mountainous areas affords difficult passage across country. Roads and trails less likely to be muddy in summer and autumn than in other seasons. Network of streams affords extensive but slow and circuitous routes of travel. Most streams navigable almost to headwaters by small boats of draft not exceeding a few feet; rapids and swift currents are hazardous; portages or aid by towing locally necessary.
V HAN CHIANG DRAINAGE BASIN	Rugged mountainous and hilly country with local small flat areas along streams. Western half predominantly hilly; eastern half prevailingly mountainous, but with hilly belts showing general NE alignment. Mountains in Fukien largely covered with forests; in Kwangtung largely deforested. Valleys generally narrow and crooked; floodplains and terraces present only locally as at bends and at stream junctions. Relief between 300 and 1,000 feet throughout greater portion of western half; between 1,000 and 3,000 feet in mountainous eastern part.	Area drains south through Han Chiang. Drainage pattern broadly rectangular for major streams; in detail an intricate, irregularly branching network. Hills and mountains furrowed by gullies and ravines occupied by intermittent and small perennial streams. Frequent and destructive floods during summer months.	Most settlements along streams, located in flats or on low rolling hills; a few small mining camps in the mountains. Flats and hill lands largely planted to wheat and irrigated rice. Kwangtung portion a double-cropping rice area; plantings in March and August, harvest in June-July and November. Tea extensively cultivated in upper part of Han Chiang valley, as around Ch'ang-t'ing.	Road net poorly developed. Routes follow valleys or wind through hilly and mountainous country. Maintenance difficult during summer months when floods may destroy valley roads and bridges. Network of trails, well developed in hilly country, connect scattered agricultural settlements. Larger streams navigable for small craft.
VI LUNG-SHIH RANGE	Rugged barrier of forested mountains averaging 15 miles in width along Fukien-Kiangsi border, expanding to 40 miles along Kwangtung-Kiangsi border. A complex of ridges and peaks with a general NE alignment separated by narrow steep-sided valleys. Higher peaks have altitudes between 6,000 and 7,000 feet. Relief generally 1,000 to 4,000 feet; greater on Kiangsi than on Fukien side.	Mountains form major drainage divide between the south and east-flowing streams of Fukien and the north- and west-flowing streams of Kiangsi. Drained by perennial and intermittent headwater tributaries of major streams in outlying areas. Gradients steep, valleys narrow.	Area sparsely settled. Small agricultural communities in lower reaches of valleys. Lumbering camps locally exploit extensive stands of virgin coniferous forest. Bamboo plantations, along mountain flanks and in valleys, cultivated for edible shoots.	Prevailingly foot trails, which cross mountains in a few widely separated localities. Two through roads cross area.
VII EAST KIANGSI HILLS AND MOUNTAINS	Hilly and mountainous country lower than bordering mountains of Map Units IV and VI and higher than the Kiangsi Lowland (Map Unit VIII) into which it drains to the north. Hills and mountains largely deforested, bare or covered with grass and scrub; aligned prevailingly NE. Summits commonly rounded; valleys generally open. Long but discontinuous flat areas along major streams; widest and most extensive along NE valleys. Relief between 300 and 1,000 feet in hilly country along major lines of NE drainage. Over 1,000 feet in mountains; locally between 2,600 and 3,300 feet; scattered high summits reach altitudes between 3,800 and 4,100 feet.	Area drains northward through two major perennial streams, the Kan-Chiang and Hsu-Chiang. NE stretches generally shallow, braided, and flanked by flood plains and low terraces; local narrow gaps where streams cut through hilly ridges. Stretches of narrow canyons in upper west-flowing reaches of Kan-Chiang. Network of perennial and intermittent streams in mountainous areas where valleys are commonly V-shaped and flood plains narrow or lacking. Widespread deforestation causes rapid runoff except in areas of permeable rock and along artificially terraced hill slopes.	No cities; population distributed among numerous agricultural and mining communities. Larger settlements along low terraces of flood plains of major streams. Many small agricultural villages except in more rugged mountains. Numerous tungsten- and coal-mining camps[c]. Flood plains and terrace land intensively cultivated in rice and sugar cane. Hillsides commonly terraced for cultivation in rice, tea, and potatoes.	Kan-Chiang and Hsu-Chiang navigable for rafts and small boats in spite of numerous sand bars and local stretches of swift water with rapids. Main roads follow valleys of major streams. North of the latitude of Ch'ang-t'ing (Unit V) network of roads is best developed of Fukien Region.
VIII KIANGSI LOWLAND	An area predominantly of flat land and low rounded hills, with small deforested mountain tracts. Valley flats along major streams locally as much as 15 miles mide; bordered by one or more natural terraces. Relief averages between 300 and 600 feet in hilly areas.	Area drained by Kan-Chiang and Hsu-Chiang, which empty into P'o-yang Hu, a large lake 60 miles beyond northern limit of map. Shallow braided rivers with sand flats; flood plains commonly several times width of stream.	Area densely populated; larger settlements along Hsu-Chiang and Kan-Chiang. Many small agricultural settlements and a few coal-mining camps in the hills. Flat lands intensively cultivated in rice and sugarcane. Hills terraced for cultivation; principal crops are rice, wheat, and beans.	Well-established river routes along Hsu-Chiang and Kan-Chiang for small, shallow-draft craft. Numerous sand bars. Main roads parallel the two major streams, following flood plains and terraces; locally subject to overflow by floods. Network of unimproved roads through valleys in hilly areas probably passable for light mechanized units.

[a] For additional information, consult other intelligence sources.
[b] See SES 139, Chekiang Region.
[c] See Mineral Resources sheet.

Prepared by U. S. Geological Survey
for Chief of Engineers, U. S. Army

CONVERSION GRAPH

Meters: 3,000 2,500 2,000 1,500 1,000 500 0

Feet: 10,000 9,000 8,000 7,000 6,000 5,000 4,000 3,000 2,000 1,000 0

EXPLANATION

- Main surfaced all-weather roads.
- Other roads; mostly unsurfaced, many poor in wet weather.
- Road destroyed in many places.
- Road probably destroyed in many places.
- Railroad.
- Railroad destroyed.

GLOSSARY

Ao ..... bay
Ch'i ..... stream
Chiang ..... river
Feng ..... mountain
Hai-kou ..... strait
Ho ..... river
Hsia ..... strait
Hsü ..... island
Lieh-tao ..... island group
Ling ..... mountain
Shan ..... island, mountain
Shui ..... river
Tao ..... island
Wan ..... bay

EXPLANATION

Flat Areas: Mud flats and sand beaches along coast; river flood plains and terraces in interior. In Areas VII and VIII pattern includes some low hilly belts with relief less than 300 feet.

Hills: Generally rolling, locally rugged country with relief 1,000 feet or less.

Mountains: Rugged country with relief generally between 1,000 and 3,000 feet.

EXPLANATION

Roman numerals and heavy lines refer to Map Units discussed in accompanying text.

I. Feng-huang Islands.
II. Chekiang Coast
III. Fukien Coast.
IV. Chekiang-Fukien Mountains.
V. Han Chiang Drainage Basin.
VI. Lung-shih Range
VII. East Kiangsi Hills and Mountains.
VIII. Kiangsi Lowland.

Reliability
Good
Fair
Poor

Scale 1:1,000,000

HEIGHTS IN METERS

Base adapted by A.M.S. and U.S.G.S. from A.M.S. 5301, 1:1,000,000, Sheets NG 50 and NG 51, 1944.

PREPARED BY U. S. GEOLOGICAL SURVEY FOR CHIEF OF ENGINEERS, U. S. ARMY

FUKIEN REGION (CHINA)

TERRAIN APPRECIATION

Reliability: Good for Map Units I, II, III, VII, and VIII, fair for Unit IV, V, and VI.
Summary report; little additional information available for more detailed studies.

Map Unit	Terrain	Movement	Observation and Concealment	Existing Cover	Excavations for Shelter
I FENG-HUANG ISLANDS	Hilly or mountainous islands up to 6 miles long with rocky summits rising from a few tens of feet to 1,400 feet above sea level. Shores are irregular and cliffed except along embayments, which are fringed with short narrow beaches.	Existing Routes[a]: Limited to trails between settlements along coast and connecting coastal and inland settlements. Cross-country Movement: Generally difficult, owing to prevailingly steep slopes in hilly and mountainous terrain; easiest on hilly Feng-huang Shan.	Observation Points: Hill and mountain summits and cliffy promontories provide many good observation points for coastal and inland areas. Visibility: Generally good; limited chiefly by topography. Restricted infrequently by fog in winter and spring. Concealment: Tall grass and scattered clumps of trees provide limited concealment from ground observation and generally inadequate concealment from aerial observation.	Topographic Cover: Ravines, steep mountainsides, and crevices in rocky slopes give local and limited cover from land fire; commonly inadequate for fire directed from sea. Artificial Cover: Structures in fishing villages provide local and generally inadequate cover for small units.	Generally possible by hand tools to depths around 6 ft in heads of larger embayments; walls likely to be unstable. Blasting in hard rock necessary over greater part of islands.
II CHEKIANG COAST	Coastal belt with shore line indented along mouths of east-flowing rivers. Larger valleys have flood plains as much as 6 miles wide near their mouths; flats a fraction of a mile to 6 miles wide border greater part of coast N of Chin-hsiang; remainder of area consists of rugged hills and mountains. Slopes in areas shown as flat land on accompanying map average 3 1/2% or less. Dissected uplands have slopes prevailingly between 15% and 45%. Relief in hilly areas generally less than 500 feet; in mountains between 1,000 and 1,500 feet.	Existing Routes[a]: Streams emptying opposite Jui-an and Ku-ao-t'ou navigable for launches and junks. Small boats can follow canals through coastal flats in area N of Chin-hsiang. Possible route from Pai-lin (Map Unit IV) to Jui-an and northward bordered by intensively cultivated lowlands N of P'ing-yang, between Ch'iao-tun-men and a point near Ku-ao-t'ou, and possibly S of Fu-ting. Cultivated lowlands generally flooded for rice between April and mid-September. Passes through hilly corridors in mountains S of P'ing-yang and between Ch'iao-tun-men and Fu-ting. Cross-country Movement: Flat areas generally passable only when dry. Raised dikes along edges of rice fields and canals offer easiest foot routes over flat areas when these are flooded. Movement across mountainous divides between major streams difficult by foot and impossible for vehicles except along established routes.	Observation Points: Numerous summits in mountainous and hilly areas command views of lowlands. Visibility: Good; hills and mountains mostly deforested. Probably greater than 6 miles on average between 20 and 28 days a month throughout year. Concealment: Tall grass on mountain slopes, crops grown on hillslopes and isolated clumps of trees provide limited concealment.	Topographic Cover: Ravines and steep valley slopes afford cover in inner parts of mountainous areas. Low stream banks provide limited cover in flat areas. Artificial Cover: Low embankments along canals and dikes in flat areas. Structures in towns and villages.	Possible by hand tools to depths around 10 ft throughout flat areas; ground water will probably be encountered at depths around 6 ft. Excavation in hilly and mountainous areas will probably require blasting.
III FUKIEN COAST	Predominantly hilly and mountainous coastal belt. Shoreline highly irregular and deeply embayed. Large streams, spaced at intervals of about 50 miles, cross area flowing E or SE. Ridges and valleys between major streams aligned prevailingly NE. Extensive mud banks, covered by shallow water, floor embayments; locally their landward margins have been reclaimed for rice cultivation. Level ground mostly around lower courses of large rivers; periodically flooded in course of intensive rice cultivation; crossed by network of small canals. Relief in hilly country averages around 500 feet; locally 1,000 feet around mountainous borders; mostly artifically terraced and intensively cultivated; slopes generally between 15% and 35%. Mountainous areas rugged, with slopes commonly between 25% and 45%; locally with cliffs. Relief 1,000 to 3,000 feet. Many islands along coast: Ssu-ming (Amoy) and Chin-men (Quemoy) predominantly hilly. Of the larger islands, Hai-t'an has the largest tracts of level ground.	Existing Routes[a]: Railroad alignment (road bed destroyed) from a mainland point opposite Ssu-ming to the Chiu-lung-Chiang. In part follows coastal areas. Main coastal route (road destroyed during war) connects Lung-ch'i and Min-hou via Chin-chiang and P'u-t'ien; crosses cultivated flats with many small canals on Nan-t'ai Island and around P'u-t'ien; elsewhere follows valleys connected by low passes; few sharp turns; grades as much as 20% in only a few passes through hilly country. Bridge across the N arm of Min-Chiang at Min-hou; bridges across Chiu-lung-Chiang, the Shuang-Ch'i and Mu-lan Ch'i are reported destroyed. Poorly developed road net through difficult country S of Nan Ch'i in southern part of area, and between Min-hou and Hsia-p'u in northern part of area; routes follow narrow valleys through mountains; many sharp turns, stretches of steep grade; unfordable streams crossed by ferries. Network of routes through hilly country between the Nan-Ch'i and Mu-lan Ch'i; many crossings of minor streams and canals; grades rarely exceed 12%; numerous cuts through crests of low hills and passes through hill gaps. Cross-country Movement: Generally easy in open hilly country; difficult for foot troops and impossible for vehicles in mountainous country. Obstructed in flat country by unfordable large streams and by canals; also impeded sporadically by floods and periodically by artificial flooding of paddy fields; generally trafficable only where drained or during dry weather. Hilly peninsular areas between Lung-ch'i and Fu-ch'ing (SE of Min-hou) permit wide deployment along variety of cross-country routes; low passes between hills passable for light vehicles. Rectangular net of canals in flat country spaced few hundred to a thousand feet apart; most 3 to 4 feet wide and around 5 feet deep. Adjoining rice fields flooded March through December in areas S of Min-hou; in area to N flooding generally between April and mid-September. Water, 6 to 10 inches deep, covers layer of mud averaging 6 in. thickness. Raised dikes along edges of rice fields are best routes of movement.	Observation Points: Numerous relatively high points throughout hilly and mountainous country. Flat areas commanded by points in adjoining hills and mountains, also by tops of taller buildings in large cities. Visibility: Generally limited only by topography. Mountains generally deforested; hillside crops no obstruction to view. Occasional fogs November through April. Concealment: Tall grass on mountain slopes and crops on hillsides give limited concealment from ground observation and generally inadequate concealment from aerial observation. Some concealment afforded by scattered stands of trees preserved locally in mountains, as around shrines.	Topographic Cover: Ravines and steep slopes afford widespread cover in mountainous areas. Large boulders up to 20 ft across on slopes of many mountains. Hilly country generally open; cover locally provided by stream banks and moderate slopes. Restricted to stream banks in flat country. Artificial Cover: Banks of canals and dikes in flat lands. Brick buildings in the cities. Numerous cemeteries, some with elaborate stone construction.	Possible by hand tools to depths around 10 ft through flat country and in greater part of hilly country. In flat areas, excavations deeper than 6 ft are likely to be flooded with ground water; sides may be unstable. Excavations in mountainous country will generally require blasting; unconsolidated material locally covers surface to depth of 3 ft.
IV CHEKIANG-FUKIEN MOUNTAINS	Rugged, predominantly mountainous country with regional slope toward E. Upland and lowland belts alike show NE alignment, roughly paralleling Fukien coast. Mountains: Comprise series of irregular ridges with prevailing NE trend, breached by gaps at intervals between a fraction of a mile and several miles; relief generally greater than 1,200 feet, locally as much as 3,500 feet; slopes generally 25% or steeper, locally rocky and cliffy, scored with ravines; crests generally rounded. No plateaus. Hilly Areas: Mostly border valleys; have numerous closely spaced conical summits, locally integrated into irregular NE ridges; slopes commonly about 25%. Relief generally around 300 ft, locally 1,000 ft. Flat Areas: Restricted to narrow discontinuous stretches along streams, especially at confluence of tributaries and in small headwater basins; most common along streams flowing NE or SW.	Existing Routes[a]: (1) Min-hou (Map Unit III) to Chien-ou; road (now has been wholly destroyed) followed winding route through mountains with many crossings over small streams. (2) Min-hou to Nan-p'ing along Min-Chiang; footpath (possibly road) follows narrow flat strips along river wherever possible; numerous short cuts through hilly country around stream bends have steep grades; probably not suitable for vehicular traffic. (3) Chin-chiang (Map Unit III) to Yung-an; road (now destroyed in large part) was suitable for light vehicular traffic; steep stretches between Ta-t'ien and Yung-an. (4) Lung-ch'i (Map Unit III) to Ch'ang-t'ing (Map Unit V); road reported destroyed near coast; steep grades between Ho-ch'i and Hsia-chuan. (5) Ma-shan-p'u to Chien-yang route through central part of area; between Ma-shan-p'u and Yung-an, grades as much as 14%, many spiral and hairpin turns, difficult or impassable for vehicles in wet weather; long corridor of easy movement from Yung-an to Chien-yang along Tashih-Ch'i and Chien-Ch'i valleys. (6) Routes from Chien-yang (focal point for traffic into Chekiang and Kiangsi Provinces): (a) N route into Chekiang via P'u-ch'eng suitable for light vehicular traffic; steep grades, many switchbacks. (b) Into Kiangsi via Ch'ung-an, route reported to be difficult. (c) Into Kiangsi via Shan-kuan, an easy route suitable for military trucks except in wet weather; ferry across stream between Ma-sha and Chieh-shou. Larger streams navigable for shallow-draft vessels. Min-Chiang is main artery for river traffic; navigable by launches from Foochow to Nan-p'ing in spite of swift currents and rapids. Cross-country Movement: Generally impossible for vehicles, difficult for foot troops; easier along NE and SW than NW and SE directions.	Observation Points: Tops of mountains and hills, and crests of ridges provide excellent observation points over extensive areas. Visibility: Limited by dense forest growth and bamboo thickets in upper reaches of Chin-Ch'i, Fu-t'un Ch'i, and Jen-ho Ch'i. Generally good elsewhere, except in small areas of tree plantations. Concealment: In area directly east of Fukien-Kiangsi boundary, forest cover provides concealment against aerial observation. Elsewhere a cover of tall grass and fern predominates, affording inadequate concealment from aerial observation and limited concealment from ground observation; scattered stands of forest in remote upland areas and around shrines provide limited concealment.	Topographic Cover: Mountainous areas with steep slopes, narrow valleys, and ravines afford widespread cover. Hilly belts with limited cover along moderate slopes and along stream banks. In flat areas, cover generally lacking; locally provided by banks of larger streams. Artificial Cover: Houses on flood plain areas commonly two-story structures with stone foundations and upper story above high-water mark. Larger settlements, as Chien-yang, commonly walled; contain a few European-type brick buildings; mostly frame structures with tile roofs.	Flat areas underlain with unconsolidated materials to depths of generally 10 feet or more provide local sites for easy excavation; walls may be unstable, subject to flooding during rainy season or because of high water table. Timber not generally available in quantity; stone from nearby hills and mountains. Hilly and mountainous areas generally underlain by rock at depths of a few inches to a few feet; may require blasting for excavation. Higher mountainous areas commonly have rock ledges exposed along summits and in ravines.

[a] See Road Construction and Maintenance Sheet; for more detailed information consult other intelligence sources.

(continued)

FUKIEN REGION (CHINA)

TERRAIN APPRECIATION

Reliability: Good for Map Units I, II, III, VII, and VIII; fair for Unit IV, V, and VI.
Summary report; little additional information available for more detailed studies.

Map Unit	Terrain	Movement	Observation and Concealment	Existing Cover	Excavations for Shelter
V HAN-CHIANG DRAINAGE BASIN	Predominantly hilly and mountainous; level land confined to narrow discontinuous flats along streams. Hilly Areas: Characterized by rounded summits sloping to open valleys; relief between 300 and 1,000 ft. Mountains: Rugged; slopes steep, locally precipitous; crests of ridges uneven with alternating saddles and conical eminences; ridges variously oriented. Relief between 1,000 and 3,000 ft.	Existing Routes a/: Main N trunk of Han-Chiang forms narrow corridor connecting Kwangtung and Fukien. Absence of continuous terraces or flood plains makes movement difficult; floods inundate valley flats. Road net poorly developed; main routes generally wind through hilly or mountainous country, avoiding river flood plains except along short stretches. Well-developed net of trails in all but mountainous areas. E-W route to Yung-an (Map Unit IV) crosses upper Han-Chiang valley through Ch'ang-t'ing and Ma-shan-p'u; liable to flooding in many sections and to gullying along eastern ascent from Han-Chiang valley. Same hazards for roads in southern part of area, where route through Lao-lung-ssu to Hsing-ning is probably maintained more easily than other stretches of same road to NE. Well-developed system of large perennial streams provides circuitous access to most parts of area by small river boats; salt shipped by boat from near P'ing-ho in southeastern part of area north to Ta-pu. Cross-country Movement: Difficult in mountains. Generally easy in hilly areas; facilitated by net of trails, many of which are probably suitable or could be improved for light vehicular traffic.	Observation Points: Innumerable ridges and summits in hilly and mountainous belts provide good points for observation. Visibility: Obstructed by forest and undergrowth in Fukien; in Kwangtung visibility generally good except in forested areas of remote uplands. Concealment: Forested area in Fukien provides good concealment both from ground and aerial observation; large bamboo plantations especially along streams. Generally deforested Kwangtung area provides limited concealment from aerial observation; tall grass and fern covering uplands give local concealment from ground observation. Groves of trees in remote uplands and around shrines.	Topographic Cover: Steep slopes of mountains, ravines, and gullies provide good and extensive cover in mountainous areas. Hilly belts provide limited cover; flats, none at all. Artificial Cover: Scattered mine workings between Mei-hsien and Chiao-ling and Tung-chou-pa may provide cover for personnel and equipment. Structures in settlements probably provide limited and local cover.	Easy in flat lands, where depth of unconsolidated material is commonly over 10 feet; shelters may fill with water; ground probably stable. Valley areas in hilly belts should offer easy excavation for shelter subject however to flooding. Hillsides and mountains generally underlain at depths of a few inches to a few feet; may require blasting for excavation. Timber and rock generally available in Fukien area; timber stands limited to remote and inaccessible portions of Kwangtung area and to areas around shrines.
VI LUNG-SHIH RANGE	Rugged dissected mountains; slopes steep, valley floors narrow. Relief between 1,000 and 4,000 ft; local elevations as high as 7,000 ft.	Existing Routes a/: Main overland route from Yung-an (Map Unit IV) to Jui-chin (Map Unit VII) crosses mountains between Ch'ang-t'ing and Jui-chin through what is probably the least difficult pass. Grade locally as much as 25%, but is passable by vehicles. Cross-country Movement: Difficult for personnel and impossible for vehicles.	Observation Points: Crests of spurs leading down from summit areas along main divide command views of surrounding lower country. Visibility: Generally poor. In higher areas commonly hindered by clouds; along flanks of mountains obstructed by dense forests and bamboo plantations. Concealment: Widespread forested tracts provide good concealment from aerial observation. Underbrush gives added concealment from ground observation.	Steep slopes and narrow valleys provide extensive topographic cover.	Excavations deeper than 2 to 3 ft generally require blasting. Hard rock is exposed at the surface over wide areas.
VII EAST KIANGSI HILLS AND MOUNTAINS	Hilly and mountainous country with discontinuous flat belts along streams. Individual hills and mountains commonly elongated along NE lines; belts of hills and mountains also with prevailingly NE alignment. Relief in hilly country between 300 and 1,000 ft. Valleys generally open; slopes commonly terraced for cultivation. Relief in mountainous country between 1,000 and 3,300 ft, with peaks standing at elevations as high as 4,100 ft. Slopes steep, valleys narrow.	Existing Routes a/: Chiang-k'ou to Jui-chin route and E trafficable except during or after heavy rains; average of one stream crossing each 0.6 mile. Nan-ch'eng to Yü-tu route follows flood plain and terraces of Hsü-Chiang to headwaters; crosses hilly divide 3 miles wide and follows flood plain of Kan-Chiang to Ning-tu; thence through hilly and mountainous country to Yü-tu; could be blocked at divide between Hsu-Chiang and Kan-Chiang headwaters, and probably at many places between Ning-tu and Yü-tu. Widely spaced roads in broad hilly belt along Kan-Chiang in NW part of area. Cross-country Movement: Easy for foot troops and probably for light mechanized units in flat and hilly areas.	Observation Points: Upper slopes and summits of hills and mountains provide many excellent observation points throughout area. Numerous hills, some with pagodas on top, rise above flood plains and terraces along corridor between Nan-ch'eng and headwaters of Hsu-Chiang and between Ning-tu and headwaters of Kan-Chiang. Visibility: Generally excellent. Concealment: Limited concealment from aerial observation afforded by sugarcane and other crops intensively cultivated in flat lands and on terraced slopes. Scattered stands of trees along rivers, mostly at settlements. Tall grass on hills and mountains affords limited concealment from aerial and ground observation.	Topographic Cover: Most extensive along narrow valleys, ravines, and steep slopes in mountainous areas; limited mostly to lower valley slopes in hilly belts. Lacking in flat areas, except along low banks at margins of streams or along breaks in slope at junction of lower and higher terraces. Artificial Cover: Structures in towns and villages provide local cover for small units. Tunnels and other underground workings of larger tungsten mines afford protection against aerial attack (see localities 7,8,9,10 and 11 on Mineral Resources sheet).	Excavations deeper than 3 ft generally impossible by hand except in flat areas and valleys through hilly areas. In flat areas, excavation by hand tools possible to depths between 3 and 10 ft.
VIII KIANGSI LOWLAND	Area of broad river flood plains and terraces flanked by rolling hills merging with scattered small mountainous tracts. Summits prevailingly aligned NE. Areas indicated as flat on accompanying map include poorly drained flood plains and their bordering terraces, the highest of which may be as much as 300 ft above valley level. Hills dissected, valleys broad and open; relief between 300 and 600 ft. Mountains S of Lin-ch'uan rise to elevations around 1,800 ft; relief between 1,000 and 1,500 ft.	Existing Routes a/: Nanking-Henan railroad route crosses NW corner of area. Main roads follow N along Kan-Chiang, Lin Shui, and Hsu-Chiang, streams which are navigable for rafts and shallow-draft boats. East of Nan-ch'eng, main route into Fukien leads through pass at Shan-kuan (Map Unit VI). Network of trails and porter roads in valleys through hilly country. Cross-country Movement: Generally easy; practically unlimited opportunities for deployment. Obstacles in flat areas are canals, sloughs, and paddy fields (flooded between April and October). Kan-Chiang and Hsu-Chiang between 2.5 and 8 ft deep and between 1,200 and 1,500 ft wide over long stretches; steep banks 12 to 25 ft high in many places. Easy movement by foot through hilly areas.	Observation Points: Summits of hills bordering main valleys command views of main roads and river routes. Visibility: Generally good throughout area. Concealment: Area largely deforested; local clumps of trees along valleys, particularly around settlements, provide limited concealment for small units.	Topographic Cover: Low natural levees, embankments along canals, and steep banks along streams provide limited cover in flat areas along major rivers. Steep slopes and ravines in isolated mountainous areas. Artificial Cover: Artificial terraces widespread through hilly country may provide cover from ground fire. Constructions in settlements and cemeteries give cover in restricted areas.	Six or more feet of unconsolidated material can be excavated by hand tools except in small isolated mountainous areas. Flat areas flooded for rice cultivation April to October; throughout year ground water encountered at depths between 3 and 4 ft in river flood plains and at depths around 6 ft on river terraces. Conditions in artificially terraced hillslopes generally similar to those on river terraces.

a/See Road Construction and Maintenance Sheet; for more detailed information consult other intelligence sources.

Prepared by U. S. Geological Survey
for Chief of Engineers, U. S. Army

VIEWS: INDEX

~~CONFIDENTIAL~~

FUKIEN REGION (CHINA)

CONVERSION GRAPH

Meters: 3,000 · 2,500 · 2,000 · 1,500 · 1,000 · 500 · 0

Feet: 10,000 · 9,000 · 8,000 · 7,000 · 6,000 · 5,000 · 4,000 · 3,000 · 2,000 · 1,000 · 0

EXPLANATION

- Main surfaced all-weather roads.
- Other roads; mostly unsurfaced, many poor in wet weather.
- Road destroyed in many places.
- Road probably destroyed in many places.
- Railroad.
- Railroad destroyed.

GLOSSARY

Ao ..... bay
Ch'i ..... stream
Chiang ..... river
Feng ..... mountain
Hai-k'ou ..... strait
Ho ..... river
Hsia ..... strait
Hsü ..... island
Lieh-tao ..... island group
Ling ..... mountain
Shan ..... island, mountain
Shui ..... river
Tao ..... island
Wan ..... bay

EXPLANATION

- Vertical aerial photograph.
- Oblique aerial photograph; arrow points in general direction of view.
- Location of ground view.

Scale 1:1,000,000

10 0 10 20 30 40 50 60 70 80 90 100 Miles

10 0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 Kilometers

HEIGHTS IN METERS

Base adapted by A.M.S. and U.S.G.S. from A.M.S. 5301, 1:1,000,000, Sheets NG 50 and NG 51, 1944.

PREPARED BY U. S. GEOLOGICAL SURVEY FOR CHIEF OF ENGINEERS, U. S. ARMY

~~CONFIDENTIAL~~

FUKIEN REGION (CHINA)

VIEWS 1-3

1. Mountainous peninsula in San-sha Hai-k'ou (Terrain Unit III). Shore bordered by submerged mud banks with branching submarine gullies. Chiao Ch'i estuary at left. Difficult cross-country movement in rugged mountains. Relatively easy movement restricted to local small areas along coast where mud flats have been reclaimed by dikes, and to narrow strips along larger valleys. (USAAF, 21PSB, M 10/14, TV 122, 123).

2. Deeply indented coast and prevailingly mountainous coastal area (Terrain Unit III); ridges trend generally NE. Larger valleys are open, relatively straight corridors; some broaden to small plains at the coast. Lowlands cleared of vegetation and cultivated in crops that offer little concealment. In mountains, local stands of timber provide concealment for personnel. View east toward San-sha Hai-k'ou and Lo-yüan Wan. (USAAF, 21 PSC, M 11/16, RO 59).

3. Narrow beach of sand and cobbles flanked by mountains, common in bay-heads of Terrain Unit III. View along west side of San-sha Hai-k'ou. Steep-sided, partly barren mountains probably typical of area. (ONI 195-297).

PREPARED BY U. S. GEOLOGICAL SURVEY
FOR
CHIEF OF ENGINEERS, U. S. ARMY

VIEWS 4-7

FUKIEN REGION (CHINA)

4. Rugged indented coast with small strips of flat land along larger valleys (Terrain Unit III). Generally bare terrain offers few possibilities for concealment against aerial observation. North shore of Lo-yuan Wan near mouth of bay. (USAAF, 21PSB, M 10/14, TV 113).

6. Hilly and mountainous country bordering Min-Chiang along approaches to Min-hou (Foochow) (Terrain Unit III). Troop movement comparatively easy near river; deployment is restricted. Rough terrain is typical of the region. (ONI 241-584).

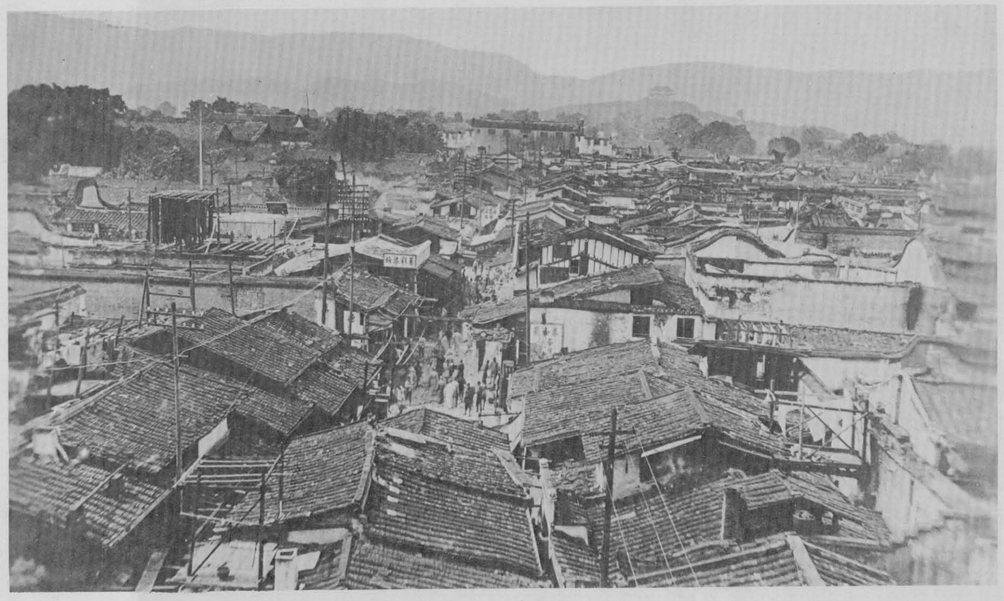
5. Broad unfordable river bordered by steep hills and mountains; largely deforested. Typical of most larger streams near coast (Terrain Unit III). Grassy and scrubby vegetation offers almost no concealment. View across south arm of Min-Chiang below Min-hou (Foochow). (ONI 326-226).

7. Steep paved mountain trail; young conifers provide poor concealment from ground and aerial observation. Most mountain trails are not paved and are not so well maintained. View from Kuliang Mountain overlooking plain on which Min-hou (Foochow) is located (Terrain Unit III). (ONI 296-364).

PREPARED BY U. S. GEOLOGICAL SURVEY
FOR
CHIEF OF ENGINEERS, U. S. ARMY

8. Road through intensively cultivated and poorly drained flat along north arm of Min-Chiang. Plains may sometimes be flooded by river; broad shifting river channels have sandy silty banks and bottoms. View of plain around Min-hou (Foochow) from Kushan, or Drum Mountain (Terrain Unit III). (Copyright, Nat. Geog. Soc., 1932, 75933-A).

9. Densely populated, intensively cultivated flat from which steep-sided hills rise abruptly; typical of coastal flats at mouths of major streams (Terrain Unit III). Plain drained through sluggish meandering sloughs and numerous canals into broad river braided with mud banks and sand bars. View of Min-hou (Foochow), north side of the Min-Chiang; bridge over river leads to Nan-t'ai. (USAAF, 21PSC, M 11/16, TV 49).



10. Crowded buildings separated by narrow crooked streets, typical of congested conditions in native sections of large cities. Movement through such sections may be difficult for columns of vehicles. View in central part of Min-hou (Foochow) (Terrain Unit III). (ONI 241-575).

11. River crowded with native boats; condition typical of rivers around larger cities, especially those near the coast. View of the Min-Chiang at Min-hou (Foochow) (Terrain Unit III). (ONI 241-591).

PREPARED BY U. S. GEOLOGICAL SURVEY
FOR
CHIEF OF ENGINEERS, U. S. ARMY

VIEWS 12-14

FUKIEN REGION (CHINA)

12. Typical estuary of Terrain Unit III; rugged hills and mountains rise abruptly above poorly drained flats with broad meandering streams and many canals. View down the Min-Chiang showing entrance of river into Formosa Strait. (USAAF, 21PSC, M 11/16, RO 46).

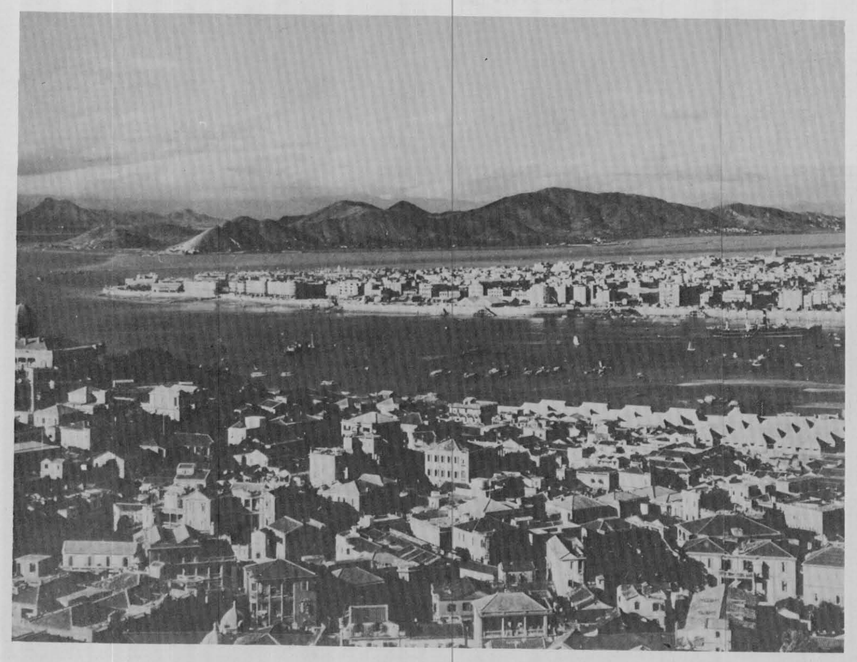
13. Intensively cultivated flat land bordered by steep-sloped hills and mountains, in large part barren. Typical of inland part of Terrain Unit III. Routes following streams pass through narrow gaps between mountains. Numerous summits, such as those in view, provide good observation points over extensive parts of lowlands. (USAAF 21PSC, M 11/16, TV 42).

14. Sandy and partly cultivated lowland trending northeast across Hai-t'an Tac (island); bordered by hills and mountains (Terrain Unit III). Flat sandy areas of this type are not common but provide a few good airfield sites along the Fukien coast. (USAAF, 21 PSB, M 10/14, TV 90).

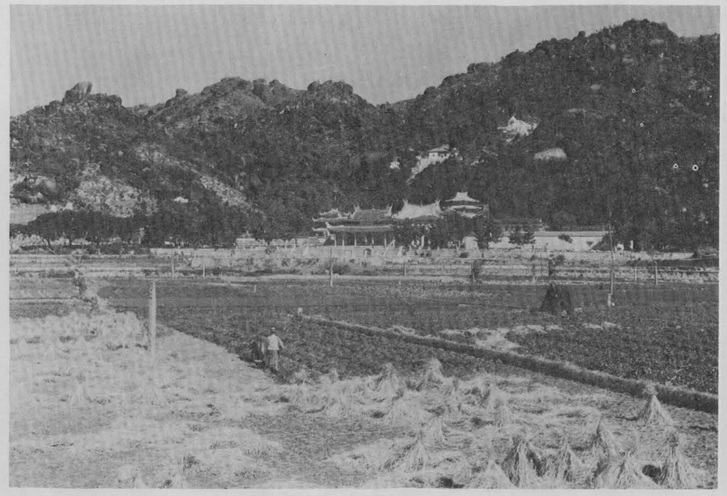
PREPARED BY U. S. GEOLOGICAL SURVEY
FOR
CHIEF OF ENGINEERS, U. S. ARMY

FUKIEN REGION (CHINA)

15. Granite quarry near Ssu-ming (Terrain Unit III). Knobs are fresh rock suitable for dimension stone and road metal; intervening areas underlain by deeply decayed bedrock. (Copyright, Nat. Geog. Soc.,1932, 75956-A).



16. One of the few cities with many buildings of stone and steel construction. View of Ssu-ming (Amoy) and adjacent mainland. Most towns in region consist of small wooden structures. Mountains in background are typical along much of Fukien coast; low flat areas are restricted mainly to estuaries (Terrain Unit III). (ONI 268.6).



17. Boulder-strewn rocky (granite) slopes rise abruptly from edge of cultivated flats near Ssu-ming (Amoy) (Terrain Unit III). Most terrain near Ssu-ming is rough rocky hill land with a few narrow flats which are intensively cultivated. Rice fields, as in foreground, are dry during harvesting; later flooded for next rice crop. (Copyright, Nat. Geog. Soc., 1932, 75957-A).

18. Rugged terrain typical of major part of region. Flat land, generally cultivated, is restricted to narrow strips along major streams. A few of these flats are possible inland sites for small emergency airfields. Vertical view of Ho-t'ung and vicinity. (USAAF, 21PSC, M 11/16, TV 66).

PREPARED BY U. S. GEOLOGICAL SURVEY
FOR
CHIEF OF ENGINEERS, U. S. ARMY

VIEWS 19-22

FUKIEN REGION (CHINA)

19. Artificially terraced and partially flooded slopes characteristic near settlements in mountainous country. Scattered groves of scrubby timber provide local and limited concealment. View south of Ku-t'ien (Terrain Unit IV). (ONI 251-569).

20. Typical rocky stream channel in grassy hill country near Ku-t'ien (Terrain Unit IV). Existing bridges away from cities, as in view, are inadequate for military vehicles. (ONI 251-571).

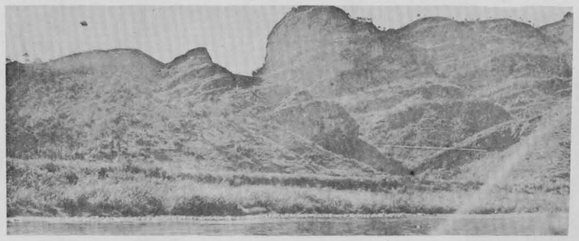
21. Mountain trail; communications in interior are largely limited to such routes. Deforested slopes are characteristic in all but the most inaccessible parts of region. View along main route following the Min-Chiang between Nan-p'ing and Min-hou (Terrain Unit IV). (ONI 240-048).

22. River corridor through mountainous country (Terrain Unit IV); such rugged terrain has led to highly developed boat traffic in central Fukien. View from Nan-p'ing down valley of the Min-Chiang. (ONI 240-031).

PREPARED BY U. S. GEOLOGICAL SURVEY
FOR
CHIEF OF ENGINEERS, U. S. ARMY

FUKIEN REGION (CHINA)

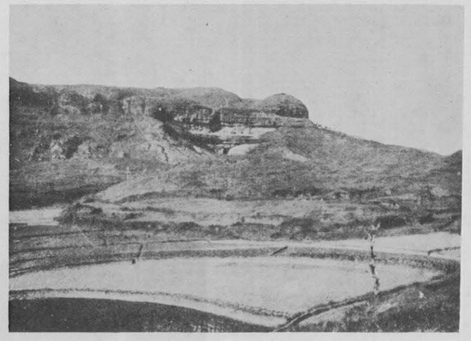
23. Typical flat area along major stream in mountains; surrounded on all sides by mountains and hills; intensively cultivated except where too sandy (Terrain Unit IV). View of walled city of Chien-ou and adjacent country along the Chien-Ch'i. Airfield on sandy flat near river; subject to flood at high water; location typical of airfields in interior Fukien. (USAAF, 21PSC, M 11/16, TV 72)



24. "Sugarloaf" and steep-sided hills carved from fragmental volcanic rocks and shale (Terrain Unit IV). Scattered trees afford limited concealment. View of hills in the Wui-Shan area west of Ch'ung-an, seen from across the Ch'ung-Ch'i. (MIS 1648.235).

25. Deep unfordable stream flowing through gorge in mountainous country (Terrain Unit VII). Most streams in mountains flow through isolated defiles of this sort. Movement along river mostly by boat and by porter trails contouring the valley sides. Gorge of the Kan-Chiang near Chiang-k'ou. (Georg Wegener, 1937).

26. Broad unfordable stream with sandy margins and low steep banks. Bare hills of sandstone and shale in background. Typical of large parts of Terrain Unit VII. View along the Kan-Chiang south of Ning-tu. Much of the traffic in Kiangsi is by river junks like those seen here. (Georg Wegener, 1926).

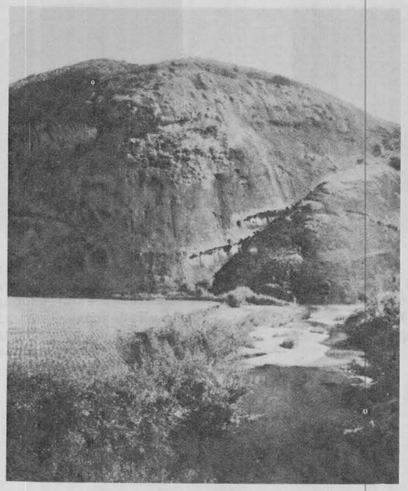


27. Rugged sandstone hills of low relief bordering rice-planted flood plain. North of Ning-tu (Terrain Unit VII). (Georg Wegener, 1926).

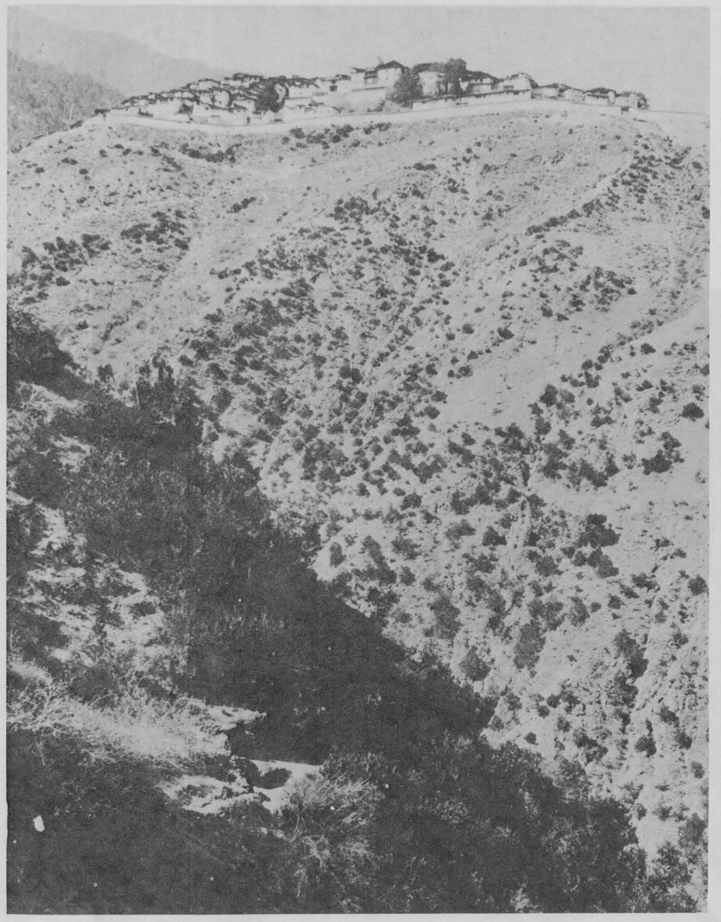
PREPARED BY U. S. GEOLOGICAL SURVEY
FOR
CHIEF OF ENGINEERS, U. S. ARMY

VIEWS 28-31

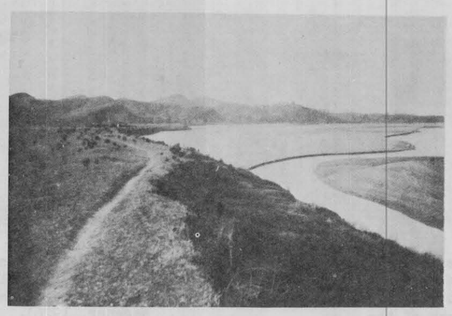
FUKIEN REGION (CHINA)



28. Bare, steep-sided rounded hills of sandstone rise abrubtly from cultivated river flood plains Terrain Unit VII. View near Kuang-ch'ang. (Georg Wegener, 1926).



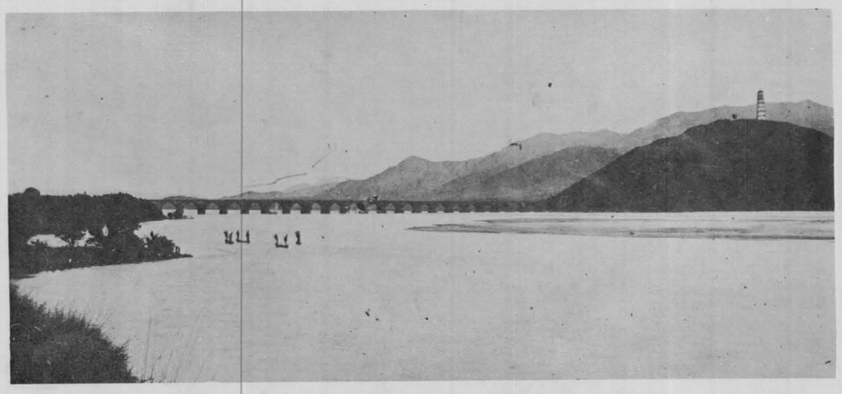
29. Mountainous country with narrow steep-sided ravines characteristic of rugged terrain between the Hsu-Chiang and Kan-Chiang drainages (Terrain Unit VII). Slopes in foreground barren and rocky with scattered scrubby plants; in background the slopes are thinly forested. Walled villages, such as this one, are characteristically located on hill crests . (ONI 317-089, Sept. 1924).



30. Broad braided stream channel with steep banks bordered by flat grassy flood plain; common along larger streams in Terrain Unit VII. Higher ground along streams is easily passable by vehicles. View along Hsu-Chiang between Nan-feng and Tseng-t'an. (Georg Wegener, 1926).

31. Typical interior lowland surrounded by rolling hills in eastern Kiangsi (Terrain Unit VII); on skyline, high rugged Lung-Shih Mountains at Kiangsi-Fukien border (Terrain Unit VI). Interior lowlands are intensively cultivated to rice, with low terraces rising gradually to hills. Provide a few good airfield sites. View near Li-ch'uan. (James Thorp, 1934, Neg. 62-1).

PREPARED BY U. S. GEOLOGICAL SURVEY
FOR
CHIEF OF ENGINEERS, U. S. ARMY



32. Terrain Unit VIII. Broad navigable braided stream with sand bars. Typically bordered by hills. Pagodas, commonly located on hill tops, provide good observation posts. Stone bridge is the same as that in View 33. View along the Hsu-Chiang at Nan-ch'eng. (ONI 251-560).

34. Typical flat rice land crossed by low dikes; view after harvest when fields are not flooded. Local groves of trees provide limited concealment. Extensive deployment in this fertile and densely populated area (Terrain Unit VIII) is possible when fields are fallow (April to October). View on flood plain of Hsu-Chiang. (Georg Wegener, 1926).

33. Typical broad alluvial flats, bordering large streams in northwestern part of region (Terrain Unit VIII). Scattered, rough hills rise steeply from plains; locally fringe stream channels. Streams are sand-choked and commonly unfordable. Extensive cultivation of rice on plains and hill slopes is characteristic in this area. Wet rice fields are the principal obstacle to movement. (USAAF. 21PSB, M 11/16, V44).

PREPARED BY U. S. GEOLOGICAL SURVEY
FOR
CHIEF OF ENGINEERS, U. S. ARMY

~~CONFIDENTIAL~~

FUKIEN REGION (CHINA)

CONVERSION GRAPH

Meters	Feet
3,000	10,000
	9,000
2,500	8,000
	7,000
2,000	6,000
1,500	5,000
	4,000
1,000	3,000
500	2,000
	1,000
0	0

EXPLANATION

- Main surfaced all-weather roads.
- Other roads; mostly unsurfaced, many poor in wet weather.
- Road destroyed in many places.
- Road probably destroyed in many places.
- Railroad.
- Railroad destroyed.

GLOSSARY

Ao	bay
Ch'i	stream
Chiang	river
Feng	mountain
Hai-hsia	strait
Ho	river
Hsia	strait
Hsü	island
Lieh-tao	island group
Ling	mountain
Shan	island, mountain
Shui	river
Tao	island
Wan	bay

EXPLANATION

1. Alluvial Valley Lowland and Coastal Plains: Surface water plentiful in many streams, generally polluted. Wells with depths of less than 30 feet have high yields; shallow ground water polluted; sanitary supplies obtainable from properly cased wells. Locally artesian water may be obtainable at depths of several hundred feet. Underlain by alluvial gravel, sand, silt, and clay. (Alluvial areas were compiled mainly from detailed maps, which do not agree in all places with drainage shown on base map; smaller areas unmapped.)
2. Terraces and Low Hills of Inland Basins: Surface water plentiful in main streams and many small tributaries; generally polluted. Wells with depths of 30 to 100 feet have moderate to high yields. Underlain by red sandy clay, soft sandstone, and sandy shale, with layers of gravel and conglomerate. Lower slopes irrigated.
3. Hills and Low Mountains of Sandstone and other Permeable Rocks: Surface water plentiful; streams not greatly polluted in upper courses; small springs common, of good sanitary quality at source. Wells with depths of 30 to 200 feet have moderate yields. Underlain by thin-bedded sandstone and shale, with minor amounts of conglomerate and fragmental lava rocks; coal beds in several districts.
4. Hills and Mountains of Dense and Relatively Impermeable Rocks: Surface water plentiful in many streams; not greatly polluted. Numerous springs of small to moderate discharge, unpolluted at source. Ground water undeveloped; wells with depths of 100 to 300 feet would have low yields. Large areas of compact granite and other hard, relatively impermeable rocks.

Scale 1:1,000,000

HEIGHTS IN METERS

Base adapted by A.M.S. and U.S.G.S. from A.M.S. 5301, 1:1,000,000, Sheets NG 50 and NG 51, 1944.

~~CONFIDENTIAL~~

PREPARED BY U. S. GEOLOGICAL SURVEY FOR CHIEF OF ENGINEERS, U. S. ARMY

FUKIEN REGION (CHINA)

WATER SUPPLY: GENERAL FEATURES

Reliability: Fair
Summary report; additional information available for more detailed reports.

INTRODUCTION

Topography: The coast line of the Fukien Region is very irregular, with many bays and promontories, and numerous rocks and small islands. The coast is bordered by disconnected bands of lowland which are less than 5 miles wide in most places but near the principal river mouths are generally 5 to 10 miles wide. In many localities the plain is very narrow, and hills rise steeply almost from the shore. In eastern Fukien the hills are in irregular groups, rising to maximum heights of 1,000 to 1,800 meters (3,300 to 6,000 feet). The interior part of the province is generally hilly or mountainous; the western boundary of the province follows a drainage divide at altitudes of 500 to 1,500 meters (1,650 to 5,000 feet). Farther west and northwest, the mean altitude decreases to less than 500 meters in the basins of large streams which drain northward. The smaller streams are in narrow valleys. For most of their courses the principal rivers also are in narrow valleys, which open in places to flat-bottomed areas several miles wide.

Precipitation: The mean annual precipitation in the coastal area ranges from about 40 inches in the south to 66 inches in the north. In the mountains of the interior the precipitation is 80 to 90 inches. Nearly all falls as rain, but there are occasional light snows in the mountains from December through February. The greater part of the rain falls from March through September, the rainiest season usually being in June, though typhoon rains may be heavy in August and September. There is no distinct dry season, but the least rain usually falls from November through January. During each of these months there is an average of about 2 inches of rain near the coast. The region is not subject to drought, as the extremes of annual rainfall depart only about 15 to 25 percent from the mean.

Streams: The region is supplied with much water by many perennial streams. Some of these flow directly to the coast, but most of them are tributary to three principal rivers. During the season of heavy rains the larger streams overflow some of the cultivated land near their channels, but seldom do much damage to crops or villages. Dikes are not extensively used to control the flood waters. The stream discharge is lowest from November through January.

Lakes: Several small natural lakes are shown on available maps, and many artificial ponds in the cultivated lands collect and control supplies of water for irrigation.

Ground Water: Dug wells in the coastal plains and along stream valleys furnish plentiful supplies of water for domestic use, from depths generally less than 30 feet. On slopes and terraces that border some of the inland valleys and basins the depth to water may be 30 to 100 feet. In hilly areas of sandstone and other permeable rocks, moderate supplies of water usually can be obtained at depths of 30 to 200 feet. Large portions of the region consist of hills and mountains of dense, relatively impermeable rocks, in some parts of which low to moderate amounts of ground water could be obtained by drilling wells to depths of 100 to 300 feet.

Water Supplies: Ample supplies of surface water of low mineral content are available nearly everywhere; but in the lowlands because of the dense population and their unsanitary habits, the water is always polluted in the lower courses of the streams. Thorough filtration and chemical treatment is therefore necessary to render surface-water supplies safe for drinking and other domestic uses. The foreign settlements in Min-hou, Ssu-ming, and Lung-yen (coal-mining town with population of about 15,000), have modern water-supply systems from adjacent streams. Elsewhere individual wells, and creeks and rivers furnish water for all purposes. Shallow ground water is plentiful in the lowlands but is also generally polluted. Sanitary supplies can be obtained in many areas by drilling wells and properly casing them to at least 20 feet below the ground-water table. Unpolluted supplies of water of low mineral content can also be obtained in many places by drilling comparatively deep wells. Brackish water might be encountered at shallow depths in some lowlands within a few hundred yards of the sea coast.

Map Unit	Summary	Surface Water (cfs=cubic feet per second gpm=gallons per minute)	Ground Water (gpm=gallons per minute)	Equipment Needed	Recommendations
1 ALLUVIAL VALLEY LOWLANDS[a] AND COASTAL PLAINS	Surface Water: Plentiful and of low mineral content, but generally turbid and highly polluted. Streams usually highest in June, occasional floods in October; lowest Nov. through Jan. Ground Water: Wells with depths less than 30 feet have high yields; unpolluted supplies can be obtained by drilling and properly casing wells. In some places within a few hundred yards of the sea coast, brackish water may be present at shallow depths. In a few localities, flowing artesian water may be obtainable at depths of several hundred feet. Many small river valleys are important for shallow ground-water supplies but are too small to be shown on map. Topography: Narrow coastal plains of gentle slope, bordered by steep hills; and stream valleys which consist of flat-bottomed areas alternating with river gorges. Alluvium generally several hundred feet thick in coastal plains; 20 to 200 feet in stream valleys. Vegetation: Intensively cultivated with quick-growing crops, chiefly rice in summer and wheat in winter; a few small, swampy uncultivated areas. Vegetables and small fruits along irrigation ditches; mulberry and other trees on mounds and other slightly higher lands. Population: Dense along coast, especially in and near principal cities; also along principal stream valleys. Probably 500 to 1,000 per sq. mile in cultivated coastal area; 300 to 500 in principal river valleys. Accessibility by Wheeled Equipment: Fair along coast and principal stream valleys; poor in small, disconnected valleys. Improved roads connect some of the principal coastal cities and traverse parts of main river valleys.	Streams[b]: Main streams have channels several feet deep in lower courses, navigated by steam launches; steep gradients in middle and upper courses, navigated by rafts and with difficulty by small boats. All streams are extensively used for irrigation; some lands are overflowed but floods infrequent and few dikes have been built. Foochow obtains about one-quarter of its water supply from Min Chiang; greatest single user is Foochow Electric Co. Lung-yen, near the head of Chiu-lung Chiang, and Nan-ping, on the Min River, obtain small municipal supplies from adjacent streams. Springs: Common along upper borders of alluvial lands; generally discharge 5 to 30 gpm; moderate mineral content, usually polluted. Largely fed by water from irrigation on nearby slopes. Three springs in Lung-yen used for public water supply. Lakes: Chiao Hu (name not on map), shallow lake 12 miles SSW of Ning-hua near western border of Fukien, has area about 3 square miles; used for water supply and irrigation. Tai Hu (name not on map), shallow lake 8 miles east of Lin-c'huan, near northwestern border of map area, has area about 1 1/2 square miles; used for water supply and irrigation. Three small lakes about 50 miles west of Pu-t'ien (Hinghwa); and 2 others near that city in small alluvial areas (not shown on map); probably other small lakes in river valleys. All are used for irrigation and domestic water supply. Many artificial ponds collect and control water for irrigation.	Kinds of Material: Coastal plains are underlain by alluvium, chiefly of sand, silt, and clay, to depths of several hundred feet. Stream valleys are underlain by sand and gravel, with minor amounts of silt and clay; generally to depths of 20 to 200 feet. Water-yielding Properties: Much water obtainable from wells with depths generally less than 30 feet, which penetrate sand and gravel layers several feet thick. In some localities, flowing artesian water may be obtainable at depths of several hundred feet. Small valleys along streams are important for shallow ground-water supplies. Quality of Water: Low to moderate mineral content; uppermost ground water polluted by farming operations. Water more than 20 feet below ground-water level generally is not polluted. In some places near sea coast, brackish water may be encountered in shallow wells; see diagram following table. Existing Wells: Many shallow dug wells supply clear water for domestic use; nearly everywhere polluted. No records of properly constructed drilled wells. Foochow obtains 75% of its water supply from wells 20 to 50 feet deep. Many shallow wells in Amoy; brackish water in lower part of city. Well Construction: Plentiful supplies can be developed by drilling or digging wells less than 30 feet. Drilled wells should be cased from surface to at least 20 feet below ground-water level, with screen or perforated casing at water-bearing zone. Largest yield will generally be obtained from wells near stream channels. Wells drilled close to sea shore may be contaminated by salt water if pumped too strongly; see diagram following table.	For Surface-water Supplies: Pumping outfits, preferably of centrifugal type; equipment for settling and filtration, storage, and chemical treatment. For Ground-water Supplies: Hand tools for digging shallow temporary wells; light portable rotary drilling rigs, casing, and screen; centrifugal or piston pumps with small power units; equipment for storage and precautionary chemical treatment.	For Combat Supplies: Water from springs, streams, or newly dug shallow wells. Must be thoroughly filtered and treated chemically. For Temporary Supplies: Springs and streams; newly dug wells; existing drilled wells if properly cased. Stream water may need preliminary settling. All water should be filtered and treated chemically. For Semi-permanent Supplies: Ground water from wells properly drilled and cased, stream and spring water, thoroughly filtered and treated chemically. Filter beds, and storage tanks or reservoirs should be provided.
2 TERRACES AND LOW HILLS OF INLAND BASINS	Surface Water: Plentiful in main streams and many small tributaries; generally clear, of low mineral content; generally polluted. Ground Water: Wells with depths of 30 to 100 feet have moderate to high yields; water has low to moderate mineral content. Unpolluted supplies obtainable by constructing drilled wells, properly cased. Topography: Slopes, low hills, and terraces bordering and in some places nearly completely occupying small inland valleys and basins. Vegetation: Lower slopes cultivated with irrigated field crops; upper slopes largely with dry field crops, tea and other shrubs, and fruit trees. Population: Moderately dense; about 300 to 500 per square mile, in many small villages; also towns of several thousand population. Accessibility by Wheeled Equipment: Fair in several valleys where roads have been constructed; poor elsewhere.	Streams[b]: Main streams are wide, shallow; clear in upper courses, turbid through irrigated lands. Small tributaries are generally clear above irrigated lands; discharge becomes small Nov. through Jan. Water of low mineral content, generally polluted. Springs: Many small springs along lower borders of terraced lands (return water from irrigation); clear but polluted. Lakes: No natural lakes reported; many artificial ponds, which collect water from small streams, used for irrigation; generally polluted.	Kinds of Material: Thick beds of soft red sandstone and sandy shale; minor layers of gravel and conglomerate. Red sandy clay at surface near north border of region. Water-yielding Properties: Plentiful amounts obtainable from wells with depths of 30 to 100 feet, which penetrate beds of gravel and soft sandstone. Quality of Water: Generally of low to moderate mineral content; noticeable amounts of iron in some localities. Not liable to be polluted if from properly cased drilled wells. Existing Wells: Many dug wells on lower slopes, for irrigation and domestic supplies. Comparatively few wells on upper slopes. Well Construction: Dug wells can be easily constructed on lower slopes. Drilled wells preferable throughout; will yield sanitary supplies of 20 to 100 gpm from gravel and soft sandstone.	For Surface-water Supplies: Easily portable centrifugal pumping outfits, with equipment for settling, filtration, and storage; light equipment for chemical treatment. For Ground-water Supplies: Hand tools for digging wells; light portable rotary or percussion drilling rigs for easily accessible districts; casing and screen, centrifugal or piston pumping units; equipment for chemical treatment.	For Combat Supplies: Water from side streams above cultivation preferable to that from main streams; water from newly-dug wells. All water should be thoroughly filtered, and treated chemically. For Temporary Supplies: Newly-dug wells; drilled wells, properly cased; water from side streams. All water should be thoroughly purified. For Semi-permanent Supplies: Preferably from wells properly drilled and cased, and chemically treated. Also water from side streams, filtered and chemically treated.
3 HILLS AND LOW MOUNTAINS OF SANDSTONE AND OTHER PERMEABLE ROCKS	Surface Water: Plentiful in many small streams; not greatly polluted in upper courses. Many small springs, of good sanitary quality at source. Ground Water: Wells with depths of 30 to 200 feet have moderate yields; water has low to moderate mineral content, is not polluted. Shallow ground water available in many small, narrow areas of stream alluvium, too small to be shown on map as Unit 1. Topography: Hills and low mountains, mainly of rounded slopes, generally rising 300 to 1,500 feet above the stream valleys; many rugged districts. Vegetation: Small cultivated areas on lower slopes; upper slopes largely in secondary forests, systematically cut for firewood and charcoal, or in dense natural forests, cut for timber. Population: Moderately dense in the lower portions; probably less than 200 per square mile throughout most of the areas. Accessibility by Wheeled Equipment: Very poor. Nearly all routes are footpaths, too narrow for ordinary wheeled vehicles; on steep slopes broad steps are cut in paths.	Streams[b]: Many perennial streams; small tributaries may become nearly dry Nov. through Jan. Water generally clear, of low to moderate mineral content; not greatly polluted in upper courses. Springs: Many hillside springs in rainy season; become low during winter. Water generally of low mineral content, not polluted at sources. Lakes: No natural lakes reported. Many artificial ponds along small streams collect and control water for irrigation of lower hillsides.	Kinds of Material: Thin-bedded sandstone and shale of various colors, with minor beds of conglomerate and fragmental lava rock. Coal beds in several districts in southern Fukien. Water-yielding Properties: Wells with depths of 30 to 200 feet have moderate yields; from sandy layers wells will yield 20 to 100 gpm. Also moderate amounts of ground water available from shallow wells in narrow areas of stream alluvium, too small to be shown on map as Unit no. 1. Quality of Water: Generally of low mineral content in sandstone and conglomerate; moderately mineralized in fragmental lava rocks. Some coal beds yield water too highly mineralized to be potable. Existing Wells: Many dug wells on lower slopes, and in narrow alluvial areas along streams. No drilled wells reported. Well Construction: Dug wells can be easily constructed. Drilled wells preferable, but access difficult for drilling equipment; moderate supplies could be developed in many areas of sandstone and of fragmental lava rocks, at locations selected on advice of ground-water geologist.	For Surface-water Supplies: Light portable centrifugal pumping units, with equipment for filtration, storage, and chemical treatment. For Ground-water Supplies: Hand tools for digging wells; small portable percussion or rotary drilling rigs, capable of rapidly sinking wells in comparatively soft materials. Light centrifugal or piston-type pumping units; filtration, and chemical treatment equipment.	For Combat Supplies: Springs and headwater streams; newly-dug wells. Thorough purification of both surface water and ground water necessary. For Temporary Supplies: Springs and headwater streams; newly-dug wells; drilled wells where easily accessible for drilling rigs. Thorough purification of all water for drinking and culinary uses necessary. For Semi-permanent Supplies: Wells drilled on the lower slopes. Springs and headwater streams. Settling and filtration of surface water, and chemical treatment of all water necessary for drinking, culinary, and other domestic supplies.
4 HILLS AND MOUNTAINS OF DENSE AND RELATIVELY IMPERMEABLE ROCKS	Surface Water: Plentiful, in many streams; not greatly polluted. Numerous springs of small to moderate discharge; unpolluted at source. Amoy has reservoir 3 miles east of city, on a small stream; capacity 270 million gallons. Ground Water: Not developed; wells with depths of 100 to 300 feet would have low yields; water probably somewhat mineralized in many places. Topography: Rugged to rounded hills and mountains, with deep ravines and small, narrow valleys. Vegetation: Lower slopes are covered chiefly by secondary forests of small evergreen trees, and scattered oaks, maples and other deciduous trees; many small cultivated tracts. Higher slopes have dense forests of fir and pine. Population: Moderate to sparse; chiefly confined to small stream valleys and adjacent slopes. Accessibility by Wheeled Equipment: Very poor; most routes are footpaths, too narrow for ordinary vehicles. Equipment could be taken up principal streams by boats of shallow draft, or by rafts.	Streams[b]: Many small streams, and several rivers of considerable size, notably sections of Min-Chiang and its main tributaries, which flow in mountain gorges for much of their courses. Least discharge Nov. through Jan.; greatest in June, July. Water generally clear, not greatly polluted; low mineral content. Springs: Many springs; of normal discharge 5 to 50 gpm; unpolluted at their sources; generally of low to moderate mineral content. Lakes: No natural lakes reported. Concrete dam on small stream forms reservoir 3 miles east of Ssu-ming (Amoy) for city water supply. Many artificial ponds on lower slopes near streams collect and control water for irrigation.	Kinds of Material: Chiefly granite in eastern and central parts of area; much hard, foliated rock in west; some lava and fragmental volcanic material locally caps hills and mesas. Water-yielding Properties: Moderate amounts obtainable at depths of 100 to 300 feet. Moderate yields available at shallow depths in narrow alluvial areas, too small to be shown on map as Unit no. 1. Quality of Water: Generally of moderate mineral content; may be noticeably mineralized in some areas of fine-grained rocks. Existing Wells: A few shallow dug wells in ravines and narrow valleys; water generally polluted. Well Construction: Shallow dug wells practicable in narrow alluvial areas. In general not favorable for drilled wells. Unpolluted water supplies could be developed by drilling wells in areas of fractured or fragmental rocks, on advice of ground-water geologist.	For Surface-water Supplies: Light portable centrifugal pumping outfits; with equipment for filtration, chemical treatment, and storage. For Ground-water Supplies: Generally not necessary to develop. Could be obtained by sinking wells by means of light portable percussion drilling rigs; probably only surface casing required, with piston or other deep-well pumping equipment. Tanks for chemical treatment and storage should be provided.	For Combat Supplies: Springs and headwater streams. Filtration and chemical treatment needed. For Temporary Supplies: Springs and headwater streams and newly-dug shallow wells. Equipment for filtration, chemical treatment and storage necessary. For Semi-permanent Supplies: Springs, headwater streams, newly-dug wells; equipment needed for filtration, chemical treatment and storage. Drilled wells, properly cased, with storage and precautionary chemical treatment, would furnish sanitary supplies.

a/ Alluvial areas were compiled mainly from detailed maps, which do not agree in all places with drainage shown on base map.

b/ Data Concerning Principal Rivers
(Similar information not available for other rivers)

Min-Chiang (Min River): Ocean vessels of 24-foot draft enter to Ma-wei (also known as Pagoda Anchorage); dredged channel to Min-hou with minimum depth of 18 feet. Maximum tidal range 19 feet at river mouth, 10 feet at Foochow; tide felt for 20 miles farther upstream. Steam launches of 5-foot draft ascend 60 miles to Shui-k'ou (at foot of lowest rapids), and to Nan-p'ing during high-water season. Smaller launches ascend north branch (Chien-Ch'i) to Chien-ou (Kienning); northwest branch (Fu-t'un Ch'i) to Shao-wu, where river was crossed by ponton bridge in 1935. Southwest branch (Ta-shih Ch'i) probably navigated to Lang-k'ou. Min-Chiang above Foochow has drainage basin of 18,500 square miles; estimated normal flood discharge 200,000 cfs, usually in June, July; low-water discharge about 5,000 cfs Dec. through Jan. River water is muddy far out to sea; turbidity highest April through July. Much organic matter and bacillus coli; greatest during low water and low tide. Water has very low hardness and low chloride content; analysis at mean stage near Foochow in 1933 showed, in parts per million: Total dissolved solids, 672; total hardness as $CaCO_3$, 15; SiO_2, 24; Fe_2O_3 and Al_2O_3, 8; CaO, 12; MgO, 7; Cl, 12; SO_3, 7.

Han-Chiang: Has drainage basin of 6,000 square miles above Ta-pu village. Usual flood discharge about 70,000 cfs; low-water discharge 1,000 cfs.

Kan-Chiang: Has drainage basin of about 29,300 square miles above town of C'hing-chiang (Linkiang). Estimated normal floods 350,000 cfs, low-water discharge 7,000 cfs. Navigated by launches to Kan-hsien (Kanchow) (not on map), a large city 12 miles southwest of Chiang-kou; native boats probably ascend main branches for many miles above Chiang-kou.

Prepared by U. S. Geological Survey
for Chief of Engineers, U. S. Army

WATER SUPPLY: GENERAL FEATURES

FUKIEN REGION (CHINA)

OCCURRENCE AND DEVELOPMENT OF GROUND-WATER SUPPLY IN COASTAL AREAS AND ON SMALL ISLANDS

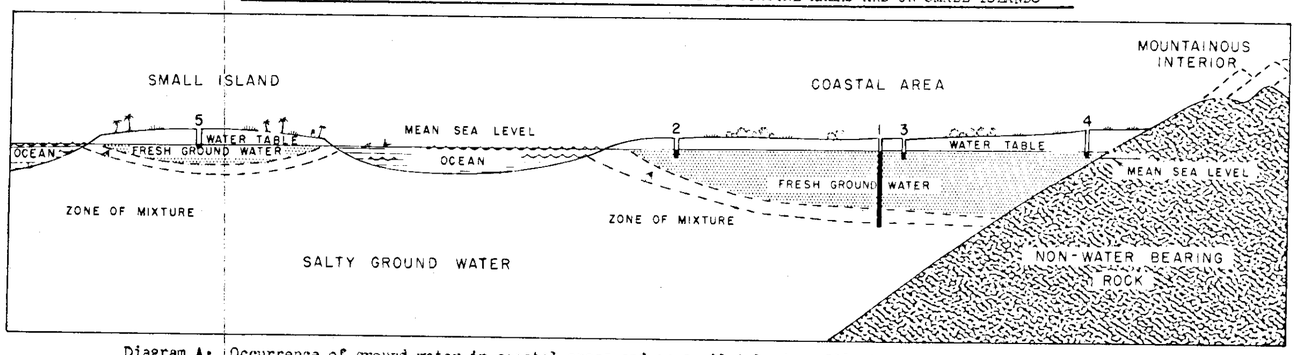


Diagram A: Occurrence of ground water in coastal areas and on small islands. Illustrates non-pumping condition of water table. During pumping, cones of depression at wells and inverted cones of salt-water intrusion are formed. Coastal areas water from a deep well (1) will be contaminated although shallow wells (2, 3, and 4) yield good supplies. Well 2 is poorly placed and will be contaminated by salt water if pumped heavily. Wells 3 and 4, are not subject to contamination because they are located farther inland. Well 4 will have less yield than Well 3 as it is underlain at shallow depth by non-water-bearing rock. On a small island wells should be shallow and located near the center of island (5). Vertical scale is considerably exaggerated.

EXPLANATION

General: In coastal areas and on small islands formed of pervious material, potable ground-water supplies can usually be obtained. However, care must be taken to avoid salty ground water by proper selection of well sites, construction of wells, and well pumpage. An understanding of the principles outlined below will facilitate development of water supplies. Proper development may enable procurement of adequate supplies in areas where good water supplies might not otherwise be obtained. This discussion refers chiefly to areas underlain by sand, gravel, or other material having a more or less uniform permeability. On islands or coastal areas underlain by alternating permeable and impermeable beds or by hard, dense, jointed rocks the problems involved are more complex and are not considered here. In such areas development of ground-water supplies is more likely to be successful if made in accordance with recommendations of a competent ground-water geologist after field investigation.

Occurrence of Fresh Ground Water: In coastal areas and on small islands the fresh ground water occurs as a thin lens which floats in hydrostatic equilibrium upon heavier, salty ground water below; normally both the height of the water table and the thickness of the fresh-water lens increase inland. Since the density of sea water is about 1.025 or 41/40ths that of fresh water, theoretically about 40 feet of fresh water lie below mean sea level for each foot of fresh water above sea level. Thus, the thickness of the fresh-water zone may be determined if the height of the water table above sea level is known. Actually, the thickness of the usable fresh-water layer is always somewhat less than the theoretical because the fresh and salt water mix slightly to form a thin intermediate, brackish zone as shown in diagram A above.

The quantity of fresh ground water obtainable in a particular area depends upon several different factors. Since the fresh ground water is derived from and replenished by rainfall, good supplies are favored by heavy, evenly distributed rainfall and by large catchment areas. In some regions having long dry periods fresh ground water may be available only during the rainy season. Good water supplies are also favored by moderate permeability. Water-bearing material with a very low permeability will yield very little water to wells; conversely, highly permeable material, especially if associated with large tidal fluctuations, favors extensive mixing and contamination by salty ground water. Mixing and contamination of the fresh water will also occur if the land rises only a few feet above high tide and is inundated by storm waves. The prospects of obtaining a good water supply also depend upon the size of the fresh ground-water body which depends in turn upon the width of the island or coastal area. It is not possible to state the minimum size of an island or width of a coastal area which will provide a satisfactory supply of potable water without evaluating all the other factors, but islands more than a mile wide and coastal lowlands more than one-quarter mile wide will generally provide adequate supplies.

Selection of Sites for Wells: On coastal areas, wells should be located a considerable distance from shore; on small islands, wells should be located in the central part of the island. Both suitable and unsuitable locations are illustrated in diagram A. Where the water-bearing materials are very permeable, as coral rock or cavernous limestone, the distance from shore should be at least several thousand feet. However, if the material has a moderate permeability, as sand, fresh water can commonly be found much nearer shore. Wells should be placed in areas of maximum ground water replenishment, as inland from head of bays or near mouths of streams; they should not be placed on narrow peninsulas, sand spits, or sand bars separated from the mainland by tidal lagoons. Vegetation may aid materially in locating good well sites by indicating the quality of shallow ground water. For example, taro plants grow only where the ground water is fresh, or slightly brackish; mangroves, nipa palms, and salt brush grow only where the ground water is salty.

All latrines, garbage dumps, burial grounds and other possible sources of pollution should be located near the shore and as far as possible from wells.

Construction of Wells: In sand and other unconsolidated material, cribbed dug wells, bored wells, drive points, and infiltration galleries can be used; but in limestone or other hard rock wells must be either dug or drilled. On small islands and narrow coastal plains wells should not extend more than one foot below sea level or several feet below the water table. Deep wells are likely to tap salt water even if placed a considerable distance inland as illustrated by well 1, diagram A. Dug wells are generally more satisfactory than single drilled or driven wells, as illustrated by wells 1 and 2 in diagram B, because they provide the same yield but have less drawdown and therefore less chance for contamination. Where the fresh water lens is thin it is advisable to distribute the pumpage throughout a wide area. Batteries of wells placed 50 feet or more apart can be used for this purpose. Where the fresh water lens is very thin it is advisable to collect the water in galleries paralleling the shore. Galleries of drainage tile, perforated steel culvert, or French drains buried not more than one foot below sea level are usually satisfactory; open trenches can be used but are subject to pollution. If large supplies are needed several batteries of wells or several infiltration galleries spaced 200 feet or more apart can be used.

Pumping: As illustrated by Well 1 in Diagram B, excessive pumping draws salt water into wells. This danger can be minimized by placing the pump inlet so that the water level cannot be lowered below sea level. Periodic measurements of the water level and titrations of the water to determine chloride content will aid materially in establishing the safe yield of each well. Where there is considerable danger of contamination it may be necessary to pump only at low tide and provide storage for periods of drought or especially high tides when pumpage will have to be reduced. If wells become salty as a result of overpumping they will freshen in time if not pumped. Any subsequent pumpage should be at a rate considerably less than the original pumpage which caused the contamination. Many wells will yield small supplies of good water when pumped occasionally with a hand pump, yet will not furnish a supply adequate for prolonged pumping or for use of a power pump. In case of extreme need wells can be pumped for short periods at rates several times that of their safe yield; however, this is inadvisable and pumping should be stopped or reduced as soon as possible.

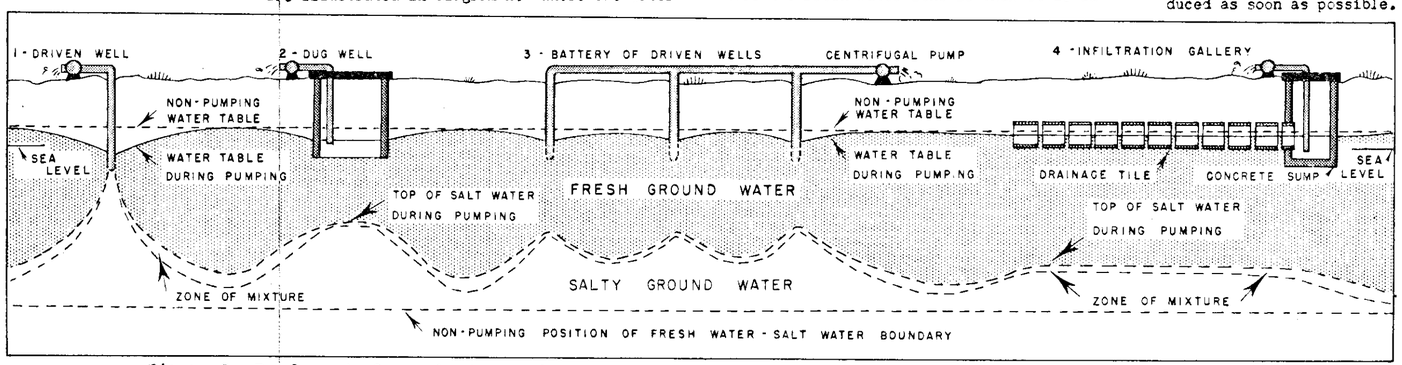


Diagram B: Development of ground-water supply in coastal areas and on small islands. Excessive pumping in small areas results in contamination of water supply (1). Note that the rise of the salt water during pumping is many times the draw-down of the water table. Contamination can be avoided by distributing the pumpage over a larger area, thereby decreasing draw-down at any one point and the maximum rise of the salt water below. Pumpage can be distributed by using a large dug well (2), a battery of driven wells (3), or an infiltration gallery (4). An infiltration gallery can be made by laying drainage tile, perforated culvert, or French drain not more than one foot below sea level in trench and backfilling. Water is pumped from a water-tight pump. Galleries are recommended where the fresh ground-water layer is only a few feet thick. Diagram is not to scale.

Prepared by U. S. Geological Survey
for Chief of Engineers, U. S. Army

FUKIEN REGION (CHINA)

WATER SUPPLY: MUNICIPAL SYSTEMS AND SEWAGE DISPOSAL

Reliability: Fair
Summary report; additional information possibly available for more detailed report.

WATER SUPPLY

GENERAL STATEMENT

In China, municipal water works are rare, and some are primitive when judged by modern standards. Treatment at many waterworks includes sedimentation and filtration but no further purification. Only about 4% of the people in this region are supplied by water from municipal waterworks. In only three or four towns are waterworks completed or under construction. Treating water with alum has been used for centuries by the Chinese. Most native drinking water is boiled and used as tea, which may partially explain an apparent native immunity against water-borne diseases. Members of a foreign military force, however, are likely to suffer serious illness by drinking any local water supplies without thorough purification.

One municipal waterworks in this area uses water from an artificial lake in the hills, one uses river water, and two use spring water. The rivers are greatly polluted by drainage from fields and gardens where human excrement is used as fertilizer. The rivers also carry large silt loads, especially at high stages. River water requires much treatment before it can be used. Water from mountain lakes or springs is much better but may be polluted from neighboring settlements.

The water is treated by filtration at the two larger plants. At the one in which river water is used, treatment is by coagulation and sedimentation. The other one is limited to filtration but water is purified with ozone, if necessary. No other details about water treatment are known. No municipal water supplies should be considered potable or usable for bathing or culinary purposes unless chlorinated; bacteriological tests must be repeated daily. Since amebic dysentery is prevalent, normal chlorination must be supplemented to maintain a residual chlorine content of at least 3 ppm[a/] for 30 minutes.

As far as known, the water-treatment plants are located near the source of water or along the aqueduct between the source and the consumption district. Distribution in town is mostly by gravity. Part of the supply goes to individual buildings and part to public taps. There is considerable danger of pollution from unclean containers used in transporting the water from public taps to the places of consumption. Water transported in these containers should be treated with halazone before being used.

In general the waterworks' capacity probably just meets the demand during the months of highest consumption, June to mid-September. During the remainder of the year, present installations are adequate to supply both normal civilian demand and a considerable military demand. The peak military demand probably will occur at different time of the day than the peak civilian demand which will alleviate water shortages by reducing the hourly peak consumption. The Chinese population wastes water by leaving private or public taps open. If, under strict military control during field operations, this waste could be eliminated or reduced, a large reserve of water would be made available. If adjustment of the municipal water supply to increased military demand becomes necessary, the period of lower consumption (mid-September through May) is the most favorable for enlargement of supply facilities and for repairs or improvements.

MUNICIPAL WATER SUPPLY SYSTEMS

Ssu-ming (Amoy)

Population: 219,974 (1935); includes international settlement with 40,250.

Date of Construction: 1924 to 1926.

Area Supplied: City of Ssu-ming including International Settlement at Kulangsu (not shown on map) on island opposite native town.

Source of Supply: Artificial lake in hills east of town; east-west length about 1,200 yards, width about 180 yards, volume about 400,000,000 gallons; W end of lake is about 2 miles southeast of harbor. In the middle of southern shore, a dam with an intake building in its center has been constructed of rubble masonry; maximum height 75 feet, length 300 feet. (See Figures 1, 2, and 3). No details on intake are known. From dam, water flows by gravity to treatment plant. Altitude of lake about 500 ft.

Aqueduct: 11-inch pipe-line carries water 2 miles west-southwest to treatment plant at an altitude of about 150 feet.

Quality of Water: No analysis available. Water from the hills probably has a low mineral content. Agricultural settlements of minor extent, located above the lake in the hills, may pollute water slightly during rainy periods.

Treatment: 4 slow sand filters, all in use when aerial photographs were taken on December 20, 1943 and June 23, 1944. 3 filters in a row, each measuring about 45 by 70 feet. The fourth filter, at a slightly lower altitude, has a surface of about 65 by 80 feet. Filters may be operated separately or in series; in the latter case, the water from the first three filters flows by gravity through the fourth filter for second filtration. Total filter surface about one third of an acre. No sedimentation at the plant, but pre-sedimentation in lake. Nothing is known about chlorination but water is purified by ozone, if necessary (probably in periods of heavy rainfall). Ozone plant is apparently located above the northeast corner of the reservoir (see next paragraph).

Reservoir: An underground clear-water reservoir is situated immediately down hill from the filter basins. Capacity was planned at 1,000,000 gallons but aerial photographs indicate a slightly smaller capacity.

Capacity: About 1,000,000 gpd[a/].

Distribution: By gravity through cast iron pipes; 12 to 4 in. diameter. Before 1929, about 10 miles of pipes were laid. In 1931, Kulangsu had a pipe network which was not directly connected with the native city. Water was supplied by a water boat, holding 105,000 gallons, and pumped from there to a reservoir on the top of a hill in the center of the island. It is not known whether a direct pipe connection with Ssu-ming water system has been constructed since. In 1929 there were 2,000 consumer connections, all metered, 40 fire hydrants and 6 public hydrants. In 1938, all new buildings in Ssu-ming and Kulangsu were reported to be connected with the water-supply system.

Consumption: Unknown.

Lung-yen

Town about 90 miles NW of Ssu-ming. Population about 15,000. Three public springs, flowing from a shale formation, are reported to supply very good cold and clear water, but it is not known whether this water is distributed by a municipal system of pipe lines.

Min-hou (Foochow)

Population: 390,363 (1934)

Date of Construction: Begun 1936; no information on stage of completion.

Area to be Supplied: International Settlement in Nan-t'ai, on island in Min-Chiang (Min River) south of Min-hou planned as first stage of development. Supply of native town on northern bank of river planned as second stage.

Source of Supply: Min River at Lung Tan Chiao (not shown on map) on south bank of river. Upstream from Lung Tan Chiao, at Nan-t'ai Bridge, river fluctuates as follows:

Highest high water	23.1 feet above zero datum at Pagoda (port of Min-hou)
Lowest low water	5.0 feet above zero datum at Pagoda (port of Min-hou)
Maximum tide	8.1 feet
Minimum tide	1.7 feet

Quality of Water: Raw water had a satisfactory chemical quality at time project was planned. After one hour of settling, the raw water, mixed with 3/4 grains alum per gallon for ten minutes, had a pH of 6.8, turbidity 1, color 5, and no alkalinity. Bacteriological tests showed that raw water was polluted to a varying degree, maximum was 12,000 bacteria per cc at 37° and 15,200 at 20° C. Bacteria coli index per 100 cc was 5,500. Only a trace of chloride was found at 30 feet depth. After full treatment, water should have satisfactory quality but will need chlorination.

Treatment: Alum coagulation with 20 minutes of mixing and 3 hours of settling; pre-sedimentation during longer periods of muddy floods. Filtration, apparently by rapid sand filters. A filter capacity of 3,600,000 gallons per day was considered sufficient; this amount could be filtered by two rapid filters of normal size. A wash water tank with a capacity of 100,000 gallons was provided at the plant. Nothing is known about chlorination.

Capacity: Total planned capacity 6,700,000 gallons per day (maximum) for all the city. First stage of construction required only half the ultimate capacity.

Reservoir: Clear-water reservoir of 700,000 gallons capacity at the plant. A second one with 400,000 gallons capacity to be expanded later to 1,500,000 gallons; probably to be located at WooSho Shan or Yu Shan (not shown on map).

Distribution: Normal demand can be met by gravity distribution. Some high sections were to be supplied by utilizing the wash-water tank. First part of project provided full coverage of Nan-t'ai, but only one main line to the native city. Sufficient fire and public hydrants were part of the project, but their number is not known.

Consumption: Unknown. Average daily consumption per capita was estimated at 10 to 13 gallon.

Nan-p'ing (Yen-p'ing)

Town about 85 miles NW of Min-hou, at the junction of two tributaries of Min-chiang (Min River); population unknown.

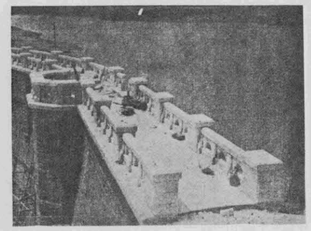
In 1925, it was reported that a small local company supplied water to the town by gravity through bamboo pipes in a very crude but effective way. Source of water is probably mountain springs in the hills around the town. Replacement of the bamboo pipes by galvanized iron pipes was started at that time.

SEWAGE DISPOSAL

There are no municipal sewerage systems in the whole area. Some towns apparently have storm sewers providing for disposal of waste, but night soil is generally saved for use as fertilizer. Lack of sewerage systems makes sanitary conditions very unsatisfactory. All military units will have to make their own arrangements for the disposal of all human waste.

Figure 1.

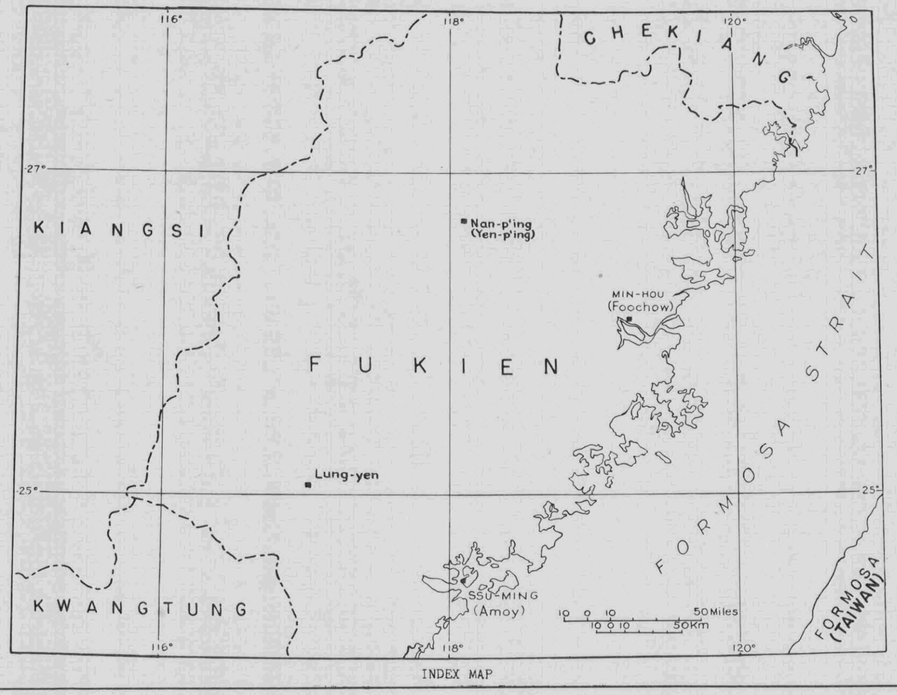
Figure 2.



DAM AND RESERVOIR FOR AMOY WATER WORKS, CHINA

Figure 3.

ARTIFICIAL LAKE FOR WATER SUPPLY FOR SSU-MING (AMOY).



INDEX MAP

a/ ppm = parts per million
gpd = gallons per day

Prepared by U. S. Geological Survey
for Chief of Engineers, U. S. Army

SUITABILITY FOR AIRDROMES

FUKIEN REGION (CHINA)

EXPLANATION

Existing Airdromes

◇ Airdromes; runways more than 5,000 feet long.

◩ Airdromes; runways 3,000 to 5,000 feet long.

\+ Emergency landing strips and airdromes; runways generally less than 3,000 feet long.

CONVERSION GRAPH

Meters / Feet

3,000 / 10,000
2,500 / 8,000
2,000 / 7,000
1,500 / 6,000
1,000 / 5,000
500 / 4,000
0 / 3,000
1,000 / 2,000
2,000 / 1,000
3,000 / 0

EXPLANATION

- Main surfaced all-weather roads.
- Other roads; mostly unsurfaced, many poor in wet weather.
- Road destroyed in many places.
- Road probably destroyed in many places.
- Railroad.
- Railroad destroyed.

GLOSSARY

Ao ..... bay
Ch'i ..... stream
Chiang ..... river
Feng ..... mountain
Hai-kou ..... strait
Ho ..... river
Hsia ..... strait
Hsü ..... island
Lieh-tao ..... island group
Ling ..... mountain
Shan ..... island, mountain
Shui ..... river
Tao ..... island
Wan ..... bay

EXPLANATION

1. Well-Drained Valley and Coastal Flats.
Each area shown contains space for at least one 6,000-foot runway with unrestricted approaches.

2. Poorly Drained Clay Plains
Generally unsuitable for rapid construction of airdromes because of poor drainage and heavy clay soil.

3. Undulating Lowlands and Low Hills.
Generally unsuitable for airdrome construction, but with some good sites. Extensive grading required.

4. Small Valley Flats.
Suitable for emergency fields only. Each area shown contains space for at least one 5,000-foot runway with one approach clear and one hazardous or blocked.

5. Mountainous Terrain
Airdrome construction impracticable because of rugged topography.

GENERALLY SUITABLE IN PART FOR AIRDROME CONSTRUCTION — MOST SUITABLE FOR AIRDROME CONSTRUCTION — GENERALLY UNSUITABLE FOR AIRDROME CONSTRUCTION

FUKIEN AIRFIELDS - RELIABILITY

Explanation
Good
Fair
Poor

Scale 1:1,000,000

HEIGHTS IN METERS

Base adapted by A.M.S. and U.S.G.S. from A.M.S. 5301, 1:1,000,000, Sheets NG 50 and NG 51, 1944.

PREPARED BY U. S. GEOLOGICAL SURVEY FOR CHIEF OF ENGINEERS, U. S. ARMY

FUKIEN REGION (CHINA)

SUITABILITY FOR AIRDROMES

Reliability of data shown by small inset map.
Summary report; some additional information available for more detailed report.

INTRODUCTION

Scope: This report is a summary of conditions affecting airdrome construction in a part of southeastern China. The area discussed (lat. 24° to 28°N, longitude 115° to 121°E) includes most of Fukien Province and parts of Chekiang, Kiangsi, and Kwangtung Provinces.

Terrain: Rugged hills and mountains occupy most of the region. Near the coast are many small, isolated delta plains and areas of low hills, and in the northwest part of the region are considerable areas of plains, low hills, and deeply trenched terraces. Elsewhere flat and gently sloping land is restricted to small isolated valley flats along major streams. Average relief is 300 to 1,000 feet near the coast and in the northwest part of the region; 2,000 to 4,000 feet in the higher mountains near the Fukien border. Valley floors and terraced hillsides are intensively cultivated, chiefly to rice; uncultivated slopes are covered with grass or low brush in most parts of the region; are forest-covered in the higher mountains. The prevailing rugged topography drastically restricts airfield construction; except in the more open valleys to the northwest, practicable sites are limited to small coastal and valley flats.

Weather Conditions: The climate is, in general, humid subtropical. Freezing temperatures are rare on the coast, but sufficiently frequent inland to be considered in the preparation of subgrade. Rainfall averages about 45 inches per year on the coast, somewhat higher inland; some rain can be expected in any month, but the period from October to February is relatively dry. Heavy rainfall accompanying thunderstorms and typhoons in summer and early fall produces frequent floods in lowland areas. Prevailing winds are northeast throughout most of the year, but in places shift strongly to south or southeast in summer; typhoons and cyclonic storms produce much variation.

Construction Problems: Stabilization of heavy clay soils and provision for adequate drainage are serious problems in flat plains areas, less serious at edges of plains and on small flats along rivers. Extensive grading is generally necessary in areas of low hills and terraces. Sand and gravel suitable for construction purposes are obtainable near most sites from stream channels or beaches. Hard rock suitable for crushing is obtainable in all parts of area except locally in northwest corner; overburden is light and quarries are easily opened. Good timber is available only in higher, relatively inaccessible parts of the mountains. Ample water is generally available.

Existing Airdromes: More than two dozen fields are reported in this area, of which about half are in Japanese-held territory along the coast. Most of the fields are small emergency landing strips; probably not more than ten or twelve are at present suitable for military use. Considerable expansion of the fields at Nan-ch'eng, Ch'ang-t'ing, Min-hou, P'u-t'ien, Chin-chiang, and Hsing-ning could be readily accomplished; limited expansion is possible at Lung-yen and Chien-ou; expansion would be possible but would require extensive grading at Ssu-ming and Chin-men Tao; for other fields the possibility of expansion cannot be judged from available data.

Map Unit	Summary Statement	Topography	Foundation and Drainage	Clearing and Grading	Construction Materials
1 WELL-DRAINED VALLEY AND COASTAL FLATS Intensively cultivated, chiefly to rice. Larger areas inland accessible by road; small valleys accessible only by trail; most areas near coast accessible only by trail because roads have been destroyed. Each area shown on map has space for at least one 6,000-foot landing strip with clear approaches at both ends (maximum glide angle 20:1).	In general, best areas for rapid construction of airdromes. Drainage good and subgrade readily stabilized. Construction materials generally available.	Gently-sloping flood plains along larger rivers; low terraces and alluvial fans trenched by shallow stream channels; gently undulating dunes and beach ridges locally on coast. Alluvial fans in places grade into poorly drained clay plains. Rice land artificially terraced; small paddy fields flooded from March to December south of Min-hou and from April to September north of Min-hou. Flooded paddy fields can be easily drained by cutting dikes. Bordering hills rise abruptly from valleys, restrict approaches locally.	Soil is clay loam to sandy loam; surface material in rice land is hard and cloddy when dry, plastic and sticky when wet. Underlying material is gravel, sand and clay. Surface drainage good; drainage through soil good except in compacted clay layer immediately below surface in rice land. In most places subgrade can be stabilized by mixing soil with underlying material and compacting at optimum moisture content; locally, addition of sand and gravel or of bitumen may be desirable; near coast addition of clay binder may be necessary in sandy areas. To prevent frost damage in valleys at high altitudes, a thick base course of gravel or crushed rock is necessary. Water table several feet below surface; adequate drainage at most sites can be maintained by shallow ditches around runway and canals above site to deflect surface run-off.	Little or no clearing required. Moderate grading needed at some sites to smooth surface irregularities; soil easily handled when dry or partly dry, difficult to work when wet.	Sand and gravel generally obtainable from stream channels and beaches; in northwest corner of area, best source of gravel probably soft conglomerate layers in red bed formations (see Geology sheet). Hard rock for crushed stone commonly available in hills, but probably scarce in northwest corner of area. Good timber available in higher parts of mountains; generally not obtainable elsewhere. Ample water obtainable from streams, springs and shallow wells.
2 POORLY DRAINED CLAY PLAINS Small deltas and reclaimed mud flats along coast; river plain in northwest corner of area. Flat or nearly so (gradients less than 1%); poorly drained, subject to floods during or after storms. Intensively cultivated, chiefly to rice. Areas near coast probably are accessible only by trail, because roads destroyed; larger areas accessible from good harbors.	Generally unsuitable for rapid construction of airdromes. Topography favorable, but drainage poor and subgrade difficult to stabilize. For permanent airdromes, raised subgrade and thick base course necessary. Best sites generally along edges of plains near hills.	Flat or nearly flat plains approximately at level of adjacent streams, cut by networks of intersecting canals. Largely cultivated to rice, in small paddy fields separated by dikes 2 to 4 feet high. Rice land flooded from March to December south of Min-hou and from April to September north of Min-hou; in part planted to dry crops during winter, in part left in wet fallow. Fields on edges of plains near hills may be quickly drained by cutting dikes, but those on low, flat parts of plains drain slowly. In some places, hills rising abruptly at edges of plains restrict approaches.	Soil is clay to clay loam; hard and cloddy when dry; plastic and sticky when wet. Some silt and sand locally near hills and along rivers; sandy layers locally underlie surface clay. Water table high, commonly within a foot or so of surface even when paddy fields are not flooded. Drainage especially poor in compacted clay layer one to two feet below surface. Poor foundation material; requires stabilization by admixture with sand or gravel and compaction at optimum moisture content, or use of thick base course. If sand and gravel are not obtainable, bitumen mixed with soil will provide fair subgrade. Adequate drainage requires raising of subgrade or provision for pumping water from ditches adjacent to site; site should be protected from surface run-off by dikes.	Little or no clearing required. Grading needed only to fill shallow fertilizer pits, to remove low dikes between paddy fields, and to raise subgrade. Soil workable when dry, but difficult to handle when wet.	Sand for stabilization of subgrade generally available in beaches or river bars. Gravel obtainable locally in bars and beach deposits, but may be difficult to find on larger plains; in northwest part of area, best source of gravel probably soft conglomerate layers in red bed formations (see Geology sheet). Rock suitable for crushed stone generally obtainable from hills adjacent to coastal plains; many good quarry sites are available on steep slopes with thin soil cover. Good timber not available. Ample water obtainable from streams, springs, and shallow wells.
3 UNDULATING LOWLANDS AND LOW HILLS Areas of low rounded hills, moderately sloping alluvial fans, and terraces trenched by ravines. In places flat or nearly flat. Largely cultivated; some areas of grass and low brush. Chief crop is rice, commonly in artificially terraced fields. Some hill areas are traversed by main roads; most are accessible only by trail from roads in nearby valleys.	Generally too rough for airdrome construction, but some good sites available. Fairly extensive grading required at most sites. In general, drainage good and subgrade easily stabilized.	Near coast, rounded hills; commonly completely covered with terraced fields; some possible sites on flat hilltops, some in valleys between hills. In interior, alluvial fans and river terraces deeply trenched by ravines; locally, flat to gently-sloping surfaces between ravines provide good airdrome sites. Gradients on hillsides steep, but at possible sites gradients average less than 5%. Rice fields readily drained by cutting dikes. Approaches generally unrestricted.	On rounded hills near coast, soil is chiefly stony clay loam; locally very thin or absent. On terraces and alluvial fans, soil ranges from clay to gravelly loam. In most places, soil is easily stabilized by compaction; in riceland, admixture of soil with underlying material is desirable. On terraces underlain by red clay in northwestern part of region (see Geology sheet) addition of sand or gravel is probably necessary for stabilization. Drainage commonly good.	Clearing of brush and small trees necessary in some places. Extensive grading required at most sites to reduce natural gradient and to smooth surface irregularities. Soil generally easy to handle, locally may be sticky when wet. Light blasting of bedrock may be necessary in areas of rolling hills where soil is thin.	At possible sites near coast, sand and gravel generally obtainable only from stream channels and beaches in adjacent areas; bedrock provides good source of crushed stone for fill, for base course, and for aggregate. In alluvial fans and some stream terraces, sand and gravel obtainable from layers beneath surface; steep ravines and terrace sides provide sites for gravel pits. In northwestern part of area, best source of gravel probably soft conglomerate layers of red bed formations; rock suitable for crushing probably difficult to find. Good timber generally not available. Adequate water for construction commonly obtainable from wells on alluvial fans and some terraces. In rolling hill land and on terraces underlain by red clay, sufficient water may not be available; must be hauled from streams or wells in adjacent areas.
4 SMALL VALLEY FLATS. Small areas of relatively flat land along mountain streams and in coastal valleys. Each area shown on map has space for at least one 5,000-foot emergency landing strip with a clear approach in one direction (maximum glide angle 20:1) and a blocked or hazardous approach in the other. Largely cultivated, chiefly to rice. Most areas accessible only by trail or by small river craft. (Many similar valleys doubtless exist in parts of the region for which no detailed topographic information is available.)	Suitable only for emergency airdromes because of small size, inaccessibility, and restricted approaches. In general, drainage good, subgrade easy to stabilize, and construction materials readily available.	Slopes up to 5%. Some valley floors flat or nearly so, some gently undulating or trenched by shallow stream channels. Rice fields in most valleys flooded during part of year, but can be quickly drained by cutting dikes. In general, hills rise steeply from valley floors.	Soils range from clay to coarse gravelly loam. In general, readily stabilized by mixing soil with underlying material and compacting. To prevent frost damage in valleys at higher altitudes, thick base course of gravel or crushed rock desirable. Drainage commonly good; poor in small valleys opening on coast.	Little or no clearing required. Moderate grading needed to smooth surface irregularities; material easily handled when dry or partly dry, but may be difficult to work when wet. In some valleys, small streams must be diverted.	Sand and gravel generally available in stream channels; quantity may be small in headwater areas of streams. Hard rock for crushed stone commonly obtainable from immediately adjacent hills. Good timber not obtainable except near remote mountain valleys. Adequate water for construction generally obtainable from streams and springs; may be scarce in valleys along small streams during winter.
5 MOUNTAINOUS TERRAIN Rugged hills and mountains; some areas of rounded hills with steep sides. Heavy timber in high mountains; small groves of trees at lower altitudes; grass and scattered brush near settlements and along large rivers. Gentler slopes planted to tea, bamboo, fruit trees and other crops; terraced grain fields in places extend far up hillsides. Except along main routes of travel, mountains accessible only by difficult trails.	Airdrome construction generally impracticable. Some valleys, flat ridge-tops and saddles probably suitable for emergency landing strips.	Generally steep slopes, sharp ridges, and V-shaped valleys; locally, rounded hills. Approaches restricted except at possible sites on ridges or saddles.	Foundation, generally in part bedrock, in part stony soil, easily stabilized by compaction. Drainage satisfactory.	Brush or timber must be cleared from most sites. Heavy grading necessary; blasting of bedrock required at many sites.	Bedrock suitable for crushed stone generally available. Sand and gravel obtainable only in valleys. Water obtainable from streams and springs.

Prepared by U. S. Geological Survey
for Chief of Engineers, U. S. Army

FUKIEN REGION (CHINA)

CONVERSION GRAPH

Meters: 3,000 2,500 2,000 1,500 1,000 500 0

Feet: 10,000 9,000 8,000 7,000 6,000 5,000 4,000 3,000 2,000 1,000 0

EXPLANATION

- Main surfaced all-weather roads.
- Other roads; mostly unsurfaced, many poor in wet weather.
- Road destroyed in many places.
- Road probably destroyed in many places.
- Railroad.
- Railroad destroyed.

GLOSSARY

Ao	bay
Ch'i	stream
Chiang	river
Feng	mountain
Hai-k'ou	strait
Ho	river
Hsia	strait
Hsü	island
Lieh-tao	island group
Ling	mountain
Shan	island, mountain
Shui	river
Tao	island
Wan	bay

EXPLANATION

1. Areas of easy road construction. Narrow discontinuous belts of flat or gently rolling land on coast and in river valleys; largely cultivated to rice.
2. Areas of moderately easy road construction. Hill land, generally in narrow belts, along coast and bordering some river flats in mountains; extensively developed only in northwest.
3. Areas of difficult road construction. Rugged mountains; slopes steep to precipitous; many deep gorges.

Reliability

- Good
- Fair
- Poor

Scale 1:1,000,000

HEIGHTS IN METERS

Base adapted by A.M.S. and U.S.G.S. from A.M.S. 5301, 1:1,000,000, Sheets NG 50 and NG 51, 1944.

FUKIEN REGION (CHINA)

ROAD CONSTRUCTION AND MAINTENANCE

Reliability: Fair
Summary report; some additional information available for more detailed report.

INTRODUCTION

General Statement: Communication lines are poorly developed in the Fukien region, owing largely to the prevailingly mountainous character of the terrain. The condition of existing roads is unknown in most cases; it may be possible in places to make roads usable for military use by repair and improvement; in many parts of the region, construction of new roads is probably necessary along alignments used by primitive roads or trails. The accompanying map shows the approximate alignments of the main existing routes as well as areas of easy, moderately easy and difficult road construction.

Existing Communications[a]: Waterways and trails are the most used routes in the Fukien region. Trails form a dense network, even crossing the highest mountains by difficult routes. All navigable streams are utilized for transportation, but only a few can accomodate craft larger than junks and rafts.

The only railway that probably still exists in the region is a section of the Nanking-Honan line, which crosses the NW part of the area. A railroad alignment (road bed destroyed) exists from a point on the mainland opposite Ssu-ming to the Chiu-lung Chiang.

Roads along coast have been destroyed in large part during the recent war years. From Min hou (Foochow) southward, an improved, all weather road is known to have reached Lung-ch'i. North of Min-hou a route, possibly developed, extends through Hsia-pu, but little information is available concerning it. The coastal roads generally followed flats or passed through hilly country; locally, where mountains come near the coast, the routes may be difficult. Many streams and canals are encountered in the coastal area; most were bridged along main roads, others crossed by ferries.

Main routes (roads now largely destroyed) extend inland from Min-hou, Chiu-chiang (ch'uanchow) and Lung-ch'i through rugged mountainous country. Steep grades, many hairpin turns, and switchbacks are reported on these routes; probably difficult, if not impassable in many places, for vehicles.

A system of roads extends through central Fukien, following larger stream valleys wherever possible; in rough mountainous sections, travel on these roads is probably complicated by steep grades and turns. From Chien-yang, roads penetrate into Kiangsi and Chekiang Provinces; from Ma-shan-p'u into Kiangsi and Kwangtung Provinces.

In the hilly country of Kiangsi the road net is more highly developed; the routes probably compare favorably with those on the Fukieu coast in ease of movement of vehicles. Little is known about roads in Kwangtung Province.

Map Unit	Topographic Control	Alignment Problems	Maintenance and Construction Problems	Streams and Stream Crossings	Construction Materials Available
1 Areas of Easy Road Construction	Flat land along coast, especially around lower courses of larger rivers, with maximum width of about 6 miles. Inland in mountainous areas, flats are restricted to narrow, discontinuous belts along streams; most common along NE-SW drainage lines. In NW part of area, broad flood plains extend beyond immediate vicinity of present stream valleys. In most of Kiangsi, includes some low hilly belts (maximum relief 300 ft) commonly cut by many open, flat-bottomed valleys. Flat land is almost entirely cultivated, largely in paddy rice. On coast, paddy fields are flooded from March through December south of Min-hou (Foochow), April to mid-September in area to north; in Kiangsi lowland, from April to October. Network of small canals throughout rice areas. Raised dikes, about 2 to 3 ft high, surround paddy fields.	Many alignments with long tangents, long-radius curves, and low gradients, especially in coastal areas. Usually ample space for alternate routes and detours. Irregularities in relief, particularly in imperfectly delineated inland flats, will locally restrict alignments and necessitate shorter tangents and shorter-radius curves to avoid steep gradients. In Kiangsi, low rolling hills included with flat lands will similarly restrict alignments.	Drainage is chief problem. Bridging is serious in many coastal plain areas. In paddy-field areas, subgrade must be raised 3 to 4 ft and large open drainage ditches cut parallel to roadways. Large quantities of coarser fraction needed to stabilize paddy clay. Paddy-field dikes easily leveled by dozer. Large culverts necessary to accomodate flood water. No clearing necessary. In coastal or valley areas where fruit trees (especially citrus) are grown, natural drainage is good, soil is sandy, and clearing is not serious problem. Red clay areas in Kiangsi lowland have good natural drainage and are easily stabilized with gravel aggregate; shallow cut and fill necessary locally.	Numerous streams; in coastal area includes wide tidal estuaries surrounded by mud flats; in interior, streams may have swift currents in places, but commonly channels are filled with sand bars and bottoms are shallow and soft. Also many irrigation canals in cultivated land. Many streams may be unfordable over long stretches. Many bridges required. Use of ponton bridges hampered by swift currents. Heavy rains may cause floods from late spring through summer. Breaching of dikes in cultivated land will also cause flooding.	Coastal Areas: Sand and gravel rare in many coastal plain areas. Locally, adjacent to mountainous stretches of coastline, available from narrow beaches. Some sand and gravel may be available from deep channels in coastal plain portions of large rivers. Sand, gravel, boulders, and hard bedrock for construction abundant in neighboring hills and mountains. Almost no timber available locally except as groves around houses and cemeteries, but timber can be rafted down rivers from inland sources. Abundant water from streams and rivers. Inland Areas: Sand abundant in extensive river bars; gravel and pebbles along many smaller streams; less commonly as bars in larger rivers. Also available as local deposits interlayered with the silt and clay alluvium, especially along mountain margins of the flat land areas. Boulders, bedrock, and some timber available from adjacent hills and mountains (See Construction Materials Maps). Abundant water from streams and rivers.
2 Areas of Moderately Easy Road Construction	Hill lands, distributed through region as follows: 1) Narrow, discontinuous strips along coast from Min-hou north; widen to more extensive areas to south; 2) Narrow belts adjoining interior valley flats in Fukien mountains; 3) Extensive areas in northern Kwangtung and eastern Kiangsi. Relief ranges from about 300 to 1,000 ft. Slopes of 15 to 35% common; probably less in extensive Kiangsi hill land. Many hilltops are rounded; slopes descend into broad, open valleys. Many important existing routes employ low passes through hill-gaps. Hill lands are mostly terraced for cultivation.	Best alignments generally restricted to river valleys. Some sections with long tangents, long-radius curves, and low gradients, alternate with many sections in which short tangents and short-radius curves are necessary to avoid steep gradients. Locally no space to easily construct alternate routes or detours.	Grading is chief problem; moderate cut and fill, considerable blasting necessary. Natural drainage commonly fair to good; drainage of terraced slopes easy by cutting terrace walls. Large culverts necessary to carry heavy runoff. In red clays (See Soils Map), spillways may be required to prevent excessive gullying. Soil conditions extremely variable. Little clearing necessary; much of area is denuded; locally some brush and a few stands of small timber (trunks usually less than 6" diameter).	Most streams in narrow hilly belts are small and swift. In extensive hilly areas inland, streams with braided channels and soft banks are common; for short stretches, streams have narrow, rocky gorges and rapids. Bridges required over most streams, except smaller ones; these may be forded, but need dugway approaches. Flooding in spring and summer may destroy bridges, roadways, and river banks.	Sand and gravel from river bars abundant. Pebbles and some boulders in smaller streams. Usable bedrock for construction is commonly available locally. In Kiangsi, much rock is unsuitable for construction; quarry sites capable of supplying large amounts of rock suitable for aggregate, riprap and masonry may be 5 to 10 or rarely 15 air-line miles from a given construction site. (See Construction Materials Map). Some small timber locally, but many areas barren except for brush; timber usually available in adjacent mountainous areas. Abundant water from streams.
3 Areas of Difficult Road Construction	Most common terrain type in region: rugged mountains, highly dissected in most places, comprise largest part of Fukien Province. Individual ridges are oriented irregularly, but regional trend of mountains is NE. Relief is at least 1,000 ft throughout, 3,000 to 4,000 ft in higher ridges; some peaks in west Fukien are 7,000 ft high. Rounded crests and conical peaks are characteristic; no plateau areas are known. Slopes are steep to precipitous, generally more than 25%. Many small gaps and ravines in ridge crests and upper slopes. Few large valleys; mainly oriented NE. Many river gorges, especially in rivers trending SE, such as Min-Chiang (Min River).	Most possible alignments are in deep, narrow river valleys. Many short-radius curves, hairpin turns, and locally steep grades will be necessary unless large scale earth-removal is undertaken. Alignments locally must leave river valleys to avoid gorges, especially in valleys trending SE (as along parts of Min-chiang from Min-hou [Foochow] to Nan-p'ing). Space for easily constructed alternate routes or detours only rarely available.	Rock excavation is chief problem. Many long side-hill cuts and much blasting necessary. In Fukien, southern Chekiang, and northern Kwangtung, most rock is hard and stands well without support; exception is soft thinly-layered rock, (See Construction Materials Map, part of Unit 3, most of Unit 4), which, however, is present only in small amounts. In Kiangsi, soft, thinly-layered platy rock is dominant; tends to slump on steep cuts. Soils in mountains are dominantly thin stony loam or clay loam. Many large culverts needed for drainage of rapid runoff on steep slopes. Clearing problem varies: some nearly bare areas; much brush; are many stands of timber, especially in less accessible parts of interior Fukien; except for few virgin stands, most timber is small, commonly 6 to 10" diameter. (See Timber Map, Figure 1, Construction Materials Sheet).	Many swift mountain streams; some larger trunk streams. Most streams have some rocky gorges and long rapids. Most are probably unfordable; will require bridges. Some small mountain streams possibly fordable, but may require dugway approaches. Sudden floods, likely to occur in spring and early summer, are hazards to roadways and bridges.	Sand, gravel, and boulders available from most streams. Much good bedrock, except in Kiangsi Province where much of bedrock is unsuitable (see Map Unit 2). Timber usually available locally, except near coast. Maximum diameter of pine or fir about 18 inches, except in virgin forests of rugged mountains along Fukien-Kiangsi border where diameters of 36 inches or more are common. Abundant water in streams.

[a]/For further information, consult other intelligence sources.

Prepared by U. S. Geological Survey
for Chief of Engineers, U. S. Army

FUKIEN REGION (CHINA)

CONVERSION GRAPH

Meters	Feet
3,000	10,000
2,500	9,000
2,000	8,000
1,500	7,000
1,000	6,000
500	5,000
0	4,000
	3,000
	2,000
	1,000
	0

EXPLANATION

- Main surfaced all-weather roads.
- Other roads; mostly unsurfaced, many poor in wet weather.
- Road destroyed in many places.
- Road probably destroyed in many places.
- Railroad.
- Railroad destroyed.

GLOSSARY

Ao	bay
Ch'i	stream
Chiang	river
Feng	mountain
Hai-kou	strait
Ho	river
Hsia	strait
Hsü	island
Lieh-tao	island group
Ling	mountain
Shan	island, mountain
Shui	river
Tao	island
Wan	bay

EXPLANATION

Suitability of Soils for Subgrade:
Green = Good; Red = Fair; Purple = Poor

Mountains
1. About 75% bare rock (high mountains); about 25% shallow stony soils, with high organic content; plastic soils in depressions; well drained on convex surfaces. Non-trafficable.
2. Shallow to locally medium-deep loam, stony loam, and clay loam over granite, and other hard massive rocks; about 50% stony land; mostly well drained. Trafficable only on roads.

Hills
3. Shallow to medium-deep clay loam and gravelly clay loam over layered rocks; about 30% stony land; generally well drained. Trafficable only on established roads.
4. Deep, crumbly and granular (lateritic) clay loam, 6-15 feet deep, over weathered rocks or gravel; generally well drained. Trafficable in dry weather except on steep slopes.
5. Loam, sandy loam, some clay loam, about 50% stony land, over redbeds (sandstone and shale); drainage good to fair except wet paddy fields. Trafficable only on gentler slopes and established roads.

Plains, River Valleys, Beaches
6. Deep sand on tidal flats, and beaches; deep sand and gravel of river beds and flood plains; water table high in river beds, low to high on beaches. Beaches trafficable when stabilized.
7. Deep plastic clayey paddy-field soils; poorly drained; many canals in delta areas, none in inland valleys. Poorly trafficable for tracked vehicles only.
8. Deep loam, silt loam, and sandy loam of paddy fields with compact clay loam subsoil over layered sand, gravel, silt, and clay, or weathered rock; poorly drained. Trafficable for tracked vehicles, or for wheeled vehicles when drained.

Map Reliability

GOOD / FAIR / GOOD / GOOD / FAIR

Scale 1:1,000,000

10 5 0 10 20 30 40 50 60 70 80 90 100 Miles
10 5 0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 Kilometers

HEIGHTS IN METERS

Base adapted by A.M.S. and U.S.G.S. from A.M.S. 5301, 1:1,000,000, Sheets NG 50 and NG 51, 1944.

PREPARED BY U. S. GEOLOGICAL SURVEY FOR CHIEF OF ENGINEERS, U. S. ARMY

FUKIEN REGION (CHINA)

Reliability: Good for coastal areas and surveyed areas inland; poor for remainder of interior (see reliability index in lower right corner of map).

Summary report; additional information available for more detailed studies.

INTRODUCTION

General Statement: The Fukien Region lies in the humid warm temperate and subtropical zones and has an average annual rainfall of more than 50 inches; rainfall is considerably higher in the mountainous areas and slightly lower along the coast. A few high ranges such as Hsien-hsia-ling and Wu-i Shan on the Fukien-Chekiang and Fukien-Kiangsi borders are snow- and ice-covered during part of each winter. The average July temperature is about 85° F.; the average January temperature is about 55° F. Owing to the warm humid climate, rock weathering produces deep soils except in rugged areas areas where erosion is rapid.

The natural distribution of vegetation is closely related to variations of climate and topography, but modification by human activity is very apparent. Mixed forest predominates and dense and extensive forest cover is found on the high ranges above altitudes of 3,000 feet along the borders between Fukien and its neighboring provinces. The lower ranges of the hill-and-valley section of Fukien and Kiangsi Provinces have generally been denuded of trees. As a result, many low-lying hills are barren or grass covered, and the small valley basins are often flooded during rainy seasons.

The coastal lowland and valley basins are used exclusively for agriculture. Vegetation in these areas consists of rice and some dry-land crops, citrus-fruit orchards, tung plantations, bamboo, and some evergreens in patches around homesteads, field corners, and cemeteries.

The types of bedrock and their topographic position directly influence soil formation. In the mountainous areas massive granitic rocks predominate; the soils, where present, are gray-brown stony or gravelly loams, usually rich in organic matter at the surface. On steep mountain slopes soils are shallow regardless of the bedrock except in a few areas of very soft rocks. In hilly areas underlain by ancient layered (metamorphic and sedimentary) rocks, soil profiles are comparatively deeper and the soil texture is generally more clayey than in soils on massive granitic rocks. In hilly regions underlain by redbeds (interbedded sandstone and shale), the soils are sandy loams and clay loams which provide good road-building material. On low hills and in well-drained lowlands are thick clayey red and yellow soils, rich in iron and aluminum oxides (lateritic). On the floors of river valleys and along shore the soils are alluvial deposits of various depths. Superimposed on a wide variety of soils are the seasonally-irrigated rice fields in which the soils are generally deep and clayey.

Suitability of Soils for Road and Airdrome Construction: In lowland areas along the coast, and in river valleys and basins in the interior, rice fields are obstacles to movement. However, except in depressions and in diked lowlands along the coast, the fields can be drained for road or airdrome construction by destroying the paddy-field dikes and providing drainage ditches. Most of the higher parts of the lowlands have friable red clayey soils which can be worked with little difficulty and offer good subgrade material. All paddy soils need addition of aggregate for stabilization.

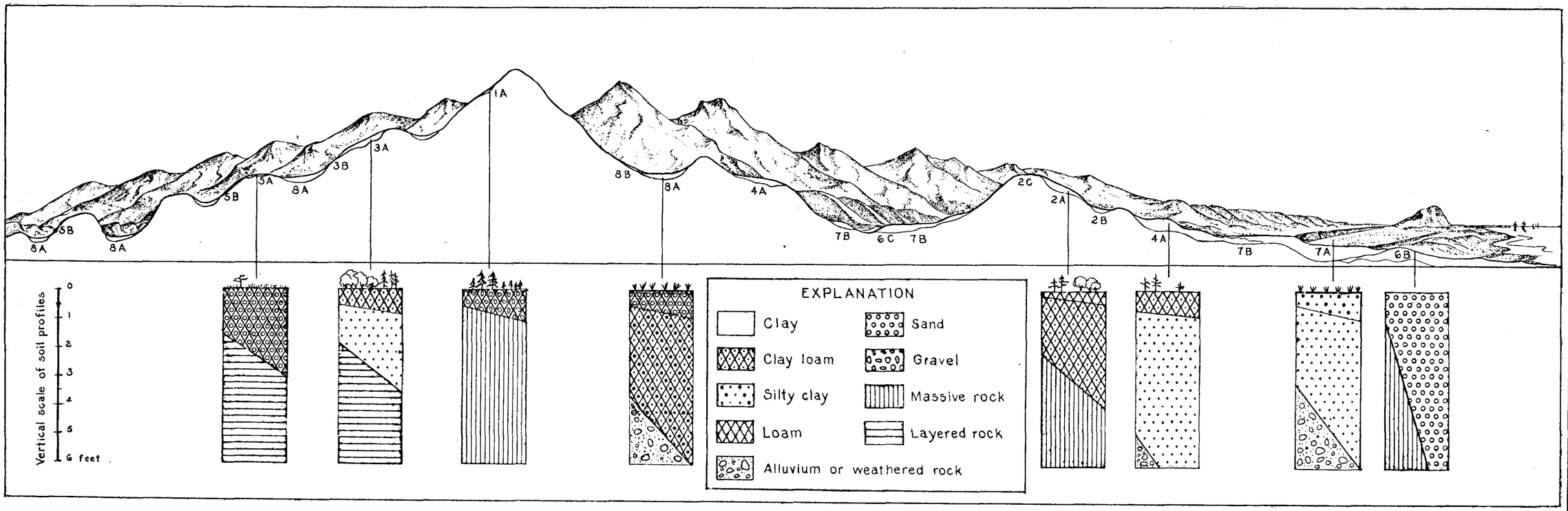
In the rugged hills and mountains in the interior of Fukien soil distribution is uneven. On most gentle slopes soil is available for road construction. The terraced paddy fields on the hillsides can be easily drained by breaking down the dikes which parallel the contours of the slopes. Material for aggregate and surfacing is available nearby.

In the high rugged mountains of the border regions between Fukien and its neighboring provinces much of the surface is bare rock and the soil where present, is thin. Much cut-and-fill will be necessary for road construction and rock will be needed for much of the fill. In the limited amount of soil available the coarse fraction is well graded and suitable for aggregate.

Classification of Soils: For engineering purposes the soils of the Fukien Region are grouped into eight units whose general distribution is shown on the accompanying map. Each soil unit is actually a group of associated soils occurring under similar physical conditions. Generalized profiles of the eight soil units accompany the diagram below. The soils map and the diagram are based on soil-survey data for parts of the region; the soil units shown for the rest of the region are based on interpretation of data on climate, vegetation, geology, and topography and their effect on soil-forming processes. Engineering group symbols and their equivalent P.R.A. classification are assigned in accordance with the usage of the War Department Technical Manual 5-255 and of the Public Roads Administration, with some modification.

Special Caution: The water of many paddy fields and streams supports a species of snail which is the intermediate host for schistosomiasis, a disease caused by a parasite which enters the body through the feet and attacks intestine walls. Men should never wade barefooted in paddy fields.

GENERALIZED DIAGRAM SHOWING RELATION OF MAP UNITS TO TOPOGRAPHY AND VEGETATION, WITH SOIL PROFILES
(Numbers indicate map units; letters refer to subdivisions of map units described in table)



(continued)

FUKIEN REGION (CHINA)

Reliability: Good for coastal areas and surveyed areas inland; poor for remainder of interior (see reliability index in lower right corner of map).
Summary report; additional information available for more detailed studies.

Map Unit a/	Description of Dominant Soils	Depth to Rock (feet)	Composition of Soils	Important Physical Characteristics	Engineering Group Symbol and PRA Class	Depth to Water Table (feet)	Surface Drainage	Permeability	Value as Subgrade Material a/	Relief and Vegetation	Construction Requirements
1	Soil only in local patches; about 75% of area bare hard rock. 1A, Slopes: Gravelly loam or loam; high organic content; 6 inches to 1 foot thick. 1B, Local Depressions: Dark organic soil over bluish plastic clay.	0 to 2	Soil, where present, gravelly loam.	1A: Plasticity low; coarse fraction well graded. 1B: Organic plastic clay.	1A: GW (A-3) 1B: OH (A-6,A-7)	—	1A: Excessive 1B: Poor	1A: High 1B: Low	1A: Fair 1B: Poor	Rough high mountains, generally above 3,000 feet. Forest of conifers and broad-leaved types. Shrub above 6,000 feet.	Land generally unsuitable for road and airdrome construction because of rough stony terrain. 1A: Needs no drainage. 1B: Will need local surface drains and culverts.
2	2A, Gentle Slopes: Grayish-brown friable stony loam, 3 to 4 inches thick. Yellowish- to reddish-brown clay loam, 1 to 3 feet thick. Gravelly and sandy weathered rock, 1 to many feet thick. 2B, Terraced Slopes: Similar to 2A, but wet because of irrigation. 2C, Steep Slopes: Bare massive rock outcrops and shallow sandy soils over granitic rocks.	0 to 20	2A, 2B: Clay, sand, some silt, over sand, little clay, silt. 2C: Sand, little clay, silt, gravel over massive rock	Plasticity low except in clay loam layer of 2A, where plasticity is medium and volume changes moderate. Coarse fraction well graded.	GF, CL (A-2, A-4)	2A: 6 plus 2B: 0 to 3 2C: —	2A: Rapid 2B: None 2C: Rapid	2A: Medium to high 2B: Low 2C: Medium to high	Fair to good	Mountainous, but less rough than Unit 1. Eroded land. Grass, mixed forest, bamboo. Paddy rice in 2B.	2A: No drainage adjustment needed. Easily stabilized. Aggregate needed for surfacing. Good bearing capacity after compaction at optimum moisture. Additional sand needed for clay loam layer. 2B: Paddy field dikes can be removed for surface drainage. Otherwise like 2A. 2C: Blasting needed.
3	3A, Gentle Slopes: Grayish-brown friable clay loam, 6 to 10 inches thick. Yellowish-brown compact clay, 2 to 3 feet thick. 3B, Steep Slopes: (Many rock outcrops) Grayish-brown gravelly loam, 8 to 16 inches thick. Weathered rock, a few inches thick. Hard and soft layered rocks of many kinds.	0 to 5	3A: Sand, silt, gravel, some clay, over clay, little silt, some sand. 3B: Sand, silt, gravel, some clay.	3A: Plasticity medium to high; volume changes moderate to large. 3B: Plasticity low; volume changes small. In places like 3A.	3A: CH (A-6) 3B: GC (A-1); some CH (A-6)	3 to many feet	3A: Medium to rapid 3B: Very rapid	2A: Low 3B: High to low	3A: Fair, locally poor 3B: Good, locally poor	Mountainous, but less rough than Unit 1. Altitude roughly 600 to 3,000 feet. Mixed forest, bamboo, grass; eroded land.	Drainage ditches, erosion control needed. Excavations necessary, in both hard and soft rocks. Bearing capacity low; unstable under wheel loads. Aggregate needed for stabilization.
4	4A, Convex Slopes: Brown granular loam or clay loam, 8 to 16 inches thick. Red granular crumbly clay, 2 to 5 feet thick. Mottled red and yellow plastic clay, 2 to 4 feet thick. Clay, some sand, silt, gravel. Weathered or hard rock. 4B, Level Land or Depressions: Similar to 4A but more yellowish and more plastic in upper 3 layers.	6 to 20	4A, surface soil: Clay, silt, some sand. 4A, 2d and 3d layers: Clay, some silt and sand. 4A, 4th layer: Clay, some sand and silt; local gravel. 4B: Similar to 4A.	4A: Plasticity medium and volume changes small for all except 3d layer in which plasticity is medium to high and volume changes moderate to large. 4B: Generally more plastic throughout than 4A.	CL (A-4, A-6) except 3d layer of 4A which is CH (A-7).	6 to 15	Good except 4B	Medium to low	Convex slopes, fair to good. Level areas, fair to poor.	Rolling to nearly level upland; gullied. Scrubby forest, coarse grass, some tea and tung trees.	Drainage needed on level areas. Sand or gravel needed for stabilization; obtainable from nearby rivers or from deep subsoil. Bearing capacity medium to high when compacted at optimum moisture with additional aggregate. Soil erosion control needed.
5	5A, Gentle Slopes: Purplish or brown granular sandy loam or loam, 1 1/2 to 3 feet thick. Clay loam in places. 5B, Steep Slopes: Largely bare rock; patches of soil similar to 5A. 5C, Terraced Slopes: Gray to purplish clay loam, 6 to 10 inches thick. Mottled gray and purplish plastic clay loam, 2 to 3 feet thick.	0 to 4	5A: Sand, clay, silt; local gravel. 5B: Where present, similar to 5A. 5C: Clay, some silt and sand.	5A, 5B: Plasticity low to medium; volume changes small to moderate. 5C: Plasticity medium to high; volume changes moderate to large.	5A, 5B: SF (A-2); locally CL (A-4) 5C: CH,CL (A-6, A-7)	0 to 10	5A, 5B: Good 5C: None	5A, 5B: Medium to low 5C: Low	Generally fair. 5B: Locally good. 5C: Locally poor.	Gently rolling to nearly level upland. Some steep stony hills. Grass, scrub forest, fruit trees. Paddy rice in 5C.	5A: No drainage needed. Some sand or gravel needed for stabilization; obtainable from nearby river beds. 5B: Rock blasting needed. 5C: Open drains needed. Sand and gravel needed for stabilization. Unstable under wheel loads unless stabilized and compacted at optimum moisture.
6	6A, Tidal Flats: Uniform fine sand and silt, at least 10 feet thick. 6B, Beach Sand and Dunes: Light- to reddish-brown sand or loamy sand; a few to tens of feet thick. 6C, River Wash: Sand and gravel bars of river beds; exposed at low water.	4 to 30 plus	6A: Very fine sand, silt. 6B: Fine to medium sand. 6C: Sand, gravel.	6A: Nonplastic; poorly graded. 6B: Nonplastic. 6C: Nonplastic; well-graded.	6A: ML,SF (A-4, A-2) 6B: SP (A-3) 6C: GW (A-3)	0 to 10; low in dunes; high in river wash.	None	High	Good to excellent	Mostly level; some dunes. Little vegetation; some shrubs and small trees.	Drainage by infiltration very good if outlets are available. Bearing capacity high when confined. Excellent fill except 6A, which is only fair. 6C good for base course; selected material good for surfacing. Compaction facilitated by addition of some clay.
7	7A, Mud Flats: Dark-gray plastic silty clay, 6 to 10 inches thick. Bluish-gray plastic clay, several feet thick. 7B, Valley Plains: Dark- to light-gray silty clay loam, 6 to 10 inches thick. Mottled gray and brown highly plastic clay, with prismatic structure.	6 to 20 plus	Upper 6-10 inches: Clay, silt, with organic matter. Below 6-10 inches: Clay, some silt.	Upper 6-10 inches: Plasticity medium; compressibility high. Below 6-10 inches: Plasticity high; volume changes large; elastic.	Upper 6-10 inches: CL,OH (A-5, A-6, A-7) Below 6-10 inches: CL,CH (A-6, A-7)	0 in wet season; 2 to 5 in dry season.	None	Nearly impermeable. Frequent floods.	Poor to very poor.	Level delta areas crossed by many canals; river valleys. Nearly all in paddy rice.	High water table. Dikes, tide gates, high subgrades required. Bearing capacity low; can be improved by addition of sand. Stabilization and compaction require rigid moisture control and addition of sand.
8	8A, Paddy Fields of Flood Plains and Fans: Light-gray friable sandy loam or loam, 6 to 10 inches thick. Yellow and gray mottled plastic clay loam or silty clay loam, 3 to 5 feet thick. Layered sand, gravel, silt, and clay. 8B, Paddy Fields of Lower Hill Slopes: Light-gray loam, 6 to 10 inches thick. Plastic mottled clay loam, 2 to 3 feet thick.	4 to 30 plus	8A: Sand, silt, little clay over clay, sand, some silt. 8B: Clay, sand, some silt.	Surface soils: Plasticity low; volume changes small. Subsoils: Plasticity medium; volume changes moderate.	8A: SF,SW (A-2, A-3) 8B: CL,CH (A-6)	0 in wet season; 2 to 3 feet in dry season.	None	Medium to low	Poor when undrained. Fair to good when drained.	Level flood plains; gentle valley slopes. Rice is principal vegetation; scattered trees and bamboo.	Paddy field dikes can be removed for surface drainage. High subgrades needed. Bearing capacity medium when compacted. Stabilization of clayey soils requires large proportion of sand or gravel. Dust control needed in autumn.

a/ Color of pattern on map indicates suitability of soils for subgrade: green = good; red = fair; purple = poor.

Prepared by U. S. Geological Survey
for Chief of Engineers, U. S. Army

CONVERSION GRAPH

Meters: 3,000 2,500 2,000 1,500 1,000 500 0

Feet: 10,000 9,000 8,000 7,000 6,000 5,000 4,000 3,000 2,000 1,000 0

EXPLANATION

- Main surfaced all-weather roads.
- Other roads; mostly unsurfaced, many poor in wet weather.
- Road destroyed in many places.
- Road probably destroyed in many places.
- Railroad.
- Railroad destroyed.

GLOSSARY

Ao	bay
Ch'i	stream
Chiang	river
Feng	mountain
Hai-kou	strait
Ho	river
Hsia	strait
Hsü	island
Lieh-tao	island group
Ling	mountain
Shan	island, mountain
Shui	river
Tao	island
Wan	bay

EXPLANATION

1. Granitic rock; hard volcanic rock with interbedded sandstone and shale; hard quartzite. (HARD ROCK ABUNDANT)
2. Hard limestone.
3. Hard to soft sandstone, shale, and slate. Some quartzite, conglomerate, and limestone. Some deeply decayed granite included, in Kiangsi. (MIXED HARD AND SOFT PLATY ROCKS)
4. Soft to hard platy rock (phyllite, slate, and schist); a little hard sandstone, conglomerate, and quartzite. Soft shale. (MOSTLY SOFT PLATY ROCKS; LITTLE HARD ROCK)
5. Friable red sandy clay; a little weathered gravel.
6. Silt and clay with some sand, gravel, and pebbles locally.
7. Silt and clay; very little or no sand and gravel. (UNCONSOLIDATED SURFACE DEPOSITS; SAND AND GRAVEL LOCALLY)
8. Sandy beaches, sandy tidal flats, and sand dunes.

EXPLANATION

- Xs(3) Quarry (Where several quarries are grouped closely, number of quarries shown by figure following symbol).
- Outcrop probably suitable for quarry; no quarry known.
- ls Limestone
- cgl Conglomerate
- ss Sandstone
- v Hard volcanic rock (rhyolite)

Reliability

- Excellent
- Good
- Fair
- Poor

Scale 1:1,000,000

HEIGHTS IN METERS

Base adapted by A.M.S. and U.S.G.S. from A.M.S. 5301, 1:1,000,000, Sheets NG 50 and NG 51, 1944.

PREPARED BY U. S. GEOLOGICAL SURVEY FOR CHIEF OF ENGINEERS, U. S. ARMY

FUKIEN REGION (CHINA)

CONSTRUCTION MATERIALS

For reliability of data see Reliability Index Map inset on Construction Materials map; also refer to Introduction on Geology sheet.
Summary report; some additional information available for more detailed studies in areas where index map shows good or excellent reliability.

ROCK, SAND, AND GRAVEL

Introduction

The Fukien Region is, on the whole, well supplied with available rock suited for construction uses. A broad area along the entire coast and extending inland across northern Fukien Province has an unlimited supply of available hard rock, much of it excellent for construction purposes. The interior of Fukien and northern Kwangtung Province is underlain by various types of rock most of which are usable. Kiangsi Province is underlain predominantly by rocks unsuited for construction purposes, but many patches of usaole rock, some excellent, are scattered throughout the province.

Known quarries are plotted on the Construction Materials map. The existence of many other quarries is demonstrated by the extensive use of stone, some of it in slabs many feet long, for bridge and building construction.

Limestone, suitable for lime, is quarried at many of the known quarries and is available from most of the areas of Map Unit 2. Small patches of similar limestone occur throughout the areas of Map Unit 3 and are probably quarried locally.

Extensive bars of sand, and locally of gravel, are abundant in most of the streams and rivers shown on the accompanying map. These are exposed at normal water level, but are submerged at high-water stage. Sand and gravel bars are restricted or absent in narrow gorges. On larger coastal plains, river bars are predominantly silty. River sand and gravel generally contain some silt, but are free from clay, and are easily washed. Pebbles are usually of hard rock and less than 2 to 3 inches in diameter. Larger pebbles and boulders occur in limited amounts along many of the smaller streams in the mountainous areas, and at junctions of these streams with broad alluvial flats.

Intermontane alluvial areas may contain patchy, interlayered deposits of sand and gravel buried by as much as 25 to 30 feet of silt and clay. If other sources of sand and gravel fail, probing or boring is recommended at points where tributaries enter the alluvial area and at points near its upper limit. These deposits will probably be below groundwater level, and a large flow of water may be encountered in working them.

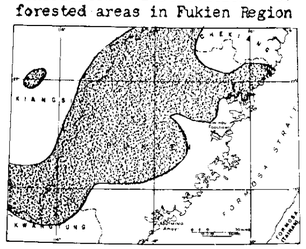
Only the larger alluvial deposits are shown on the Construction Materials map; many small unmapped flats along streams and rivers will provide limited amounts of sand and gravel.

Beaches, sandy tidal flats, and dunes along much of the coast furnish an abundance of medium-to fine-grained, clean, poorly graded quartzose sand. The widest and most extensive of these deposits are shown on the map as Map Unit 8. Beach gravel and boulders are restricted to very narrow strips along rocky, mountainous portions of the coastline where transportation is difficult.

Abundance of Hard Rock	Map Unit	Type of Material[a/]	Excavability	Suitability for Aggregate	Suitability for Riprap and Masonry	Overburden[b/]	Suitability of Overburden for Fill and Subgrade
ABUNDANT	1	Granite, banded granitic rock. Hard volcanic rock (rhyolite): hard, cemented volcanic ash and rubble with interbedded volcanic conglomerate, sandstone, and shale. Hard quartzite.	Drilling and blasting required.	Excellent to fair.	Excellent to fair.	Thin stony loam. Locally, on areas of low relief, 5 to 15 feet of red, friable, sandy clay, especially on granite.	Fair to good substitute for gravel.
	2	Hard limestone.	Drilling and blasting required.	Excellent.	Excellent.	Thin stony clay soil.	Poor substitute for gravel. Plastic when wet.
MODERATELY ABUNDANT	3	Hard to soft sandstone, interbedded shale and slate; some quartzite, conglomerate, and limestone. Locally some deeply decayed granite, especially in Kiangsi.	Drilling and blasting required. Most shale and some soft sandstone workable by dozer.	Excellent to poor.	Excellent to poor.	Thin stony clay loam predominates.	Poor to good substitute for gravel. Soil from shale swells when wet.
SCARCE	4	Soft platy rock (phyllite) and shale; some soft to hard platy rock (slate and schist); some hard sandstone, conglomerate, and quartzite.	Commonly workable to a depth of 10 to 20 feet below the surface with dozer or power shovel. Hard sandstone, conglomerate, and quartzite and deep cuts in platy rocks will require drilling and blasting.	Platy rocks unsuitable to poor. Interlayered hard sandstone, conglomerate, and quartzite, fair to good.	Platy rocks unsuitable to fair. Hard sandstone. quartzite, and some conglomerate, good to excellent.	Clayey soil, some hard rock fragments.	Unsuitable to poor. Clay swells when wet.
NONE (UNCONSOLIDATED MATERIAL)	5	Red, friable, sandy clay; patches and beds of weathered gravel, commonly underlying clay.	Workable with power shovels, dozers, or hand tools.	Unsuitable except for local weathered gravel, which makes poor to fair aggregate.	Unsuitable.	No overburden.	No overburden. Red, sandy clay is good when properly compacted with sheepsfoot roller. Local areas lacking sandy soil need added sand or gravel for stabilization.
	6	Silt and clay of intermontane alluvial areas and some coastal-plain areas. Subordinate amounts of sand, gravel, and pebbles in river bars and interbedded locally in silt and clay alluvium. Some sand, gravel, and locally pebbles and boulders, along margins of intermontane alluvial areas where small streams enter from mountains.	Workable with hand or power tools. Water table usually 5 to 30 feet below the surface.	Sand and gravel good to excellent. Some river sand may require washing. Silt and clay unsuitable.	Unsuitable.	Heavy clay paddy-field soil 3 to 4 feet thick over silt and clay in most places.	Unsuitable. Moderately to highly plastic when wet.
	7	Silt and clay of most coastal-plain areas. Little sand or gravel, except in a few places in deep river channels.	Workable with hand or power tools. Water table high, commonly less than 6 feet below surface.	Not suitable.	Not suitable.	Heavy clay paddy soil 3 to 4 feet thick over silt or clay.	Unsuitable. Moderately to highly plastic when wet.
	8	Sandy beaches, sandy tidal flats, and sand dunes. Medium- to fine-grained, clean, poorly graded, quartz sand. Dune sand may be loamy.	Workable with hand or power tools or dragline. Some of this unit submerged at high tide.	Excellent for fine aggregate.	Unsuitable.	No overburden except thin sandy loam on old dunes.	No overburden. Clay or silt binder needed to stabilize sand.

a/ For details of distribution of specific rock types see Geology map and table.
b/ For additional information see Soils Sheet.

Figure 1.
Generalized distribution of forested areas in Fukien Region



Forested areas.

TIMBER

Much of the interior of Fukien Province is forested, predominately with conifers. Except for virgin forests in the very rugged, inaccessible mountain range forming the boundary between Fukien and Kiangsi Provinces, most of the region has been and is being lumbered and the trees are not large. Along most of the coastal area, especially south of Min-hou (Foochow), and inland in Kiangsi Province, the country has been almost entirely denuded of forest cover. Standing timber in these areas is restricted to small scattered patches in the hills and to scattered trees and small groves around houses and in cemeteries.

The broad outlines of the major forested areas in the region are shown on the small inset map (Figure 1). The forested areas on this map include localities where timber is very spotty. and exclude many small wooded patches.

Within the forested portions, a small lumbering operation probably could be set up within 5 to 10 miles of most construction sites. Construction sites without local timber but near large rivers can be supplied with timber rafted down from mountain sources.

The most common timber trees in the region are pine, fir, and bamboo. Maximum diameter of pine and fir is probably less than 18 inches, except in virgin forests along the boundary between Fukien and Kiangsi Provinces, where diameters exceed 3 feet. Bamboo, locally used in many ways, is light and strong, and commonly grows to diameters of 5 to 6 inches. It occurs as forests and as thickets grown near villages for local use.

PREPARED BY U. S. GEOLOGICAL SURVEY
FOR
CHIEF OF ENGINEERS, U. S. ARMY

FUKIEN REGION (CHINA)

CONVERSION GRAPH

Meters	Feet
3,000	10,000
	9,000
2,500	8,000
	7,000
2,000	6,000
1,500	5,000
	4,000
1,000	3,000
	2,000
500	1,000
0	0

EXPLANATION

- Main surfaced all-weather roads.
- Other roads; mostly unsurfaced, many poor in wet weather.
- Road destroyed in many places.
- Road probably destroyed in many places.
- Railroad.
- Railroad destroyed.

GLOSSARY

Ao	bay
Ch'i	stream
Chiang	river
Feng	mountain
Hai-kou	strait
Ho	river
Hsia	strait
Hsü	island
Lieh-tao	island group
Ling	mountain
Shan	island, mountain
Shui	river
Tao	island
Wan	bay

EXPLANATION

- Qal — Recent alluvium: Unconsolidated clay and silt; some sand and gravel.
- Qc — Pleistocene red clay: Friable lateritic clay, some weathered gravel.
- Tr — Tertiary redbeds: Soft to moderately hard, massive, brick-red sandstone, pebble conglomerate; some thin-bedded, sandy shale.
- Krh — Cretaceous acid volcanics: Rhyolite and quartz porphyry flows and intrusions; hard, cemented pyroclastics (tuff, tuff agglomerate, volcanic conglomerate); associated red sandstone and shale.
- Kr — Cretaceous redbeds: Soft, purple-red shale with some thin-bedded, moderately hard, red sandstone and conglomerate; interbedded tuff, agglomerate, and andesitic breccia locally predominant.
- Jc — Jurassic coal-bearing series and Triassic (?) shale: Moderately hard to hard sandstone; some shale and conglomerate. Thin coal beds.
- Pzs — Middle and Upper Paleozoic sedimentary rocks: Hard sandstone, soft to hard shale; a little slate, conglomerate, quartzite, and limestone.
- pDps — Pre-Devonian phyllite, slate and schist: Phyllite and slate, some mica schist, a little thin-bedded quartzite, thin-bedded sandstone, and conglomerate.
- pKsm — Pre-Cretaceous (undifferentiated) sedimentary and metamorphic rocks: Includes Jc, Pzs, and pDps.
- gr — Granitic rocks: Granite and granite-gneiss. Pre-Cambrian (?) to early Tertiary in age. May include large areas of phyllite and mica schist.

Reliability

- Excellent
- Good
- Fair
- Poor

Scale 1:1,000,000

10 5 0 10 20 30 40 50 60 70 80 90 100 Miles

10 0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 Kilometers

HEIGHTS IN METERS

Base adapted by A.M.S. and U.S.G.S. from A.M.S. 5301, 1:1,000,000, Sheets NG 50 and NG 51, 1944.

PREPARED BY U. S. GEOLOGICAL SURVEY FOR CHIEF OF ENGINEERS, U. S. ARMY

FUKIEN REGION (CHINA)

For reliability see Introduction and Reliability Index map inset on Geology map.
Summary report; some additional information available for more detailed studies in areas where index map shows good or excellent reliability.

INTRODUCTION

Source and Reliability of Data: The geology of the Fukien Region is imperfectly known. Over the greater part of the region, the only available source of information is the Taiwan sheet of the Geologic Atlas of Eastern Asia, a Japanese reconnaissance map of poor reliability, published on a scale of 1:2,000,000.

Small portions of the region are covered by more reliable source material. The northwest corner of the quadrangle is described in considerable detail by reports of the Geological Survey of Kiangsi, accompanied by geologic maps on a scale of 1:200,000. Other areas are described in considerable detail by reports of the Geological Surveys of China, of Kiangsi, and of Kwangtung and Kwangsi. The scale of available geologic maps ranges from 1:50,000 for several very small areas to 1:1,000,000 for two geologic route-maps.

In compiling the map it was found that the Taiwan sheet, although completely unreliable in the delineation of the various age units of the pre-Cretaceous sedimentary rocks, shows the general distribution and broad outline of the redbeds, the granitic rocks, and the volcanics. Accordingly, in the large portion of the region where this map was the only source these rock boundaries were adjusted to the base map and all the older sediments and metamorphics grouped as "pre-Cretaceous sedimentary and metamorphic rocks."

Stratigraphic Summary: The Fukien Region is underlain by granitic rocks and acid volcanics, clastic sediments ranging in age from Devonian to early Tertiary, and metamorphic rocks. A pre-Devonian metamorphic complex of phyllite, schist, and gneiss is overlain unconformably by upper Paleozoic and Jura-Triassic clastic sediments which range in thickness from 5,000, to 10,000 feet. These are in turn unconformably overlain by 3,000 to 6,000 feet of continental redbeds, acid volcanic flows, and pyroclastics of Cretaceous age. In the western part of the region, several thousand feet of early Tertiary continental redbeds unconformably overlie the Cretaceous and older rocks. Large intrusions of granitic rock have occurred at two periods. The earlier invasion accompanied the movement period responsible for the widespread late Jurassic unconformity; the later accompanied the early Tertiary movement period.

Folding and faulting, caused largely by the late Jurassic and early Tertiary movements, have produced a pronounced northeasterly structural trend.

Map Unit	Rock Types	Lithology	Structure	Topographic Expression
Qal RECENT ALLUVIUM	Unconsolidated deposits of clay, silt, sand, gravel, and boulders.	Clay and silt deposits of small coastal-plain deltas and intermontane river valleys make up most of map unit. Subordinate amounts of sand and gravel present as small coastal beaches, extensive river bars; also as buried lenses, and patches in the silt and clay deposits. Coarse gravel and boulders probably restricted within map unit to very narrow beaches along rocky coastlines, to bed and bar deposits in mountainous portions of river drainage systems, and to small deposits where mountain streams enter broader alluvial areas. Many small deposits of sand, gravel, and boulders found along smaller streams and rivers, but are not shown on map. Alluvium usually less than 30 feet thick except in larger basins and coastal plains where thickness may be several hundred feet.	Horizontal or very gently sloping irregular beds. Individual beds of local extent only.	Flatlands in general. Narrow coastal flood plains, beaches, and intermontane river valleys with slopes generally less than 3%. Alluvial terraces as much as 35 to 40 feet above present river level occur along many river valleys in Kiangsi Province. Locally, along margins of mapped alluvial areas, slopes may be as steep as 15 to 25%, where Chinese geologic maps appear to include slump and talus debris in the deposits mapped as alluvium.
Qc PLEISTOCENE RED CLAY	Red clay, with gravel interbedded locally.	Friable red lateritic clay probably derived by weathering, both from old terrace alluvium and various terraced bedrocks, particularly phyllite and redbeds. Present only in Kiangsi Province. Small patches of interbedded weathered gravel in some localities where clay is derived from old alluvium or redbeds. Thickness ranges from 15 to 65 feet.	Nearly structureless. Residual gravel lenses preserve original nearly horizontal bedding in old alluvium or inclined bedding in redbeds.	Forms eroded terraces from 65 to 100 feet high in the larger river valleys of Kiangsi Province. In places, minutely dissected; detailed forms are smoothly rounded broad ridges and narrow V-shaped gullies with local relief of 10 to 20 feet. Elsewhere relief is somewhat greater; red clay forms low, undulating hills 40 to 50 feet high.
Tr TERTIARY REDBEDS	Soft to moderately hard, massive or thick-bedded brick-red sandstone, pebble conglomerate, and relatively minor thin-bedded sandy shale intercalations.	In areas near Chiang-k'ou, Yu-tu, and Lo-k'ou-tang (A-3)[a] and area around Ts'ung-jen (B-1), conglomerate forms lower part of unit; massive sandstone with thin conglomerate intercalations forms upper part. Conglomerate consists of sub-angular to well-rounded pebbles, commonly as large as 4 inches diameter, of granite, quartzite, limestone, older red sandstone, and phyllite. Formation is non-marine, early Tertiary; overlies unconformably all older rocks. Thickness 1,000 to 2,000 feet near Yu-tu; 2,300 to 2,600 feet around Ts'ung-jen.	Gently folded into NNE-trending basins; nearly horizontal and low-dipping beds common; a few dips as steep as 70° near edges of basins. Jointing poorly developed; some faults of moderate displacement.	Steep-sided, nearly flat-topped hills, sugarloafs, some blocky butte-like forms; hills commonly isolated in broad, flat-bottomed valleys. Inclined resistant beds locally form hogbacks. Local relief about 200 to 250 feet; maximum about 600 feet. Soil cover lacking or very thin; bare rock on steep slopes; a few caves and natural bridges. Upper part of unit commonly eroded to rolling hill land.
Krh CRETACEOUS ACID VOLCANICS	Rhyolite and quartz-porphyry flows and intrusions, hard cemented pyroclastics (tuff, tuff agglomerate, volcanic conglomerate); associated red sandstone and shale.	This unit is correlative with the Cretaceous redbeds of western Fukien and eastern Kiangsi; differs in the widespread occurrence of rhyolite and quartz porphyry and the predominance of volcanic material. Southern Fukien : (C-3, D-3) Two groups: Upper group 650 or more feet thick, of rhyolite, extrusive and intrusive quartz porphyry, interbedded with hard cemented tuff, agglomerate, and some andesite. Colors white, light gray, brown and purple. Lower group 650 to 1,000 feet thick, of dark gray agglomerate and tuff, or thick-bedded red sandstone and intercalated shale, locally with quartz pebble basal conglomerates. Northern Fukien: 3 groups. Upper group consists of thick rhyolite and quartz-porphyry flows. Middle group composed of hard pyroclastics: agglomerate and fine and coarse cemented tuff; also volcanic conglomerate and some red sandstone and shale. Lower group, quartz-porphyry flows, tuff, and black and gray shale. Total thickness 6,500 feet. Northeastern Kwangtung: More than 1,500 feet of thick rhyolite flows.	Moderately folded along northeast trend. Dips of 30° to 45° predominate. Strongly jointed and fractured. Two persistent sets of joints or fractures, approximately at right angles.	Underlies very rugged mountainous country. Slopes of 70% and knife-edged ridges common; many cliffs and extensive outcrops; soil cover thin. Intricately dissected; to a great extent erosion is controlled by joints or fractures; single trends may persist for as much as 5 miles. Commonly, topographic expression of bedding is subordinate. Local relief commonly 1,000 to 2,000 feet, maximum more than 3,000 feet.
Kr CRETACEOUS REDBEDS	Two main types. (1) Non-volcanic type: Soft shale with some thin-bedded moderately hard sandstone and conglomerate. (2) Interbedded-volcanic type: Claystone with interbedded tuff (locally predominant), agglomerate, and andesitic breccia	The non-volcanic type consists of purplish-red shale, green sandy shale, some thin-bedded sandstone and minor conglomerate, commonly basal. Conglomerate contains various rock types including hard sandstone, quartz, limestone, very little granite; pebbles are subangular to moderately rounded. The interbedded-volcanic type varies from a facies dominantly of fragile blood-red and indigo claystone interbedded with tuff and arkosic sandstone, to a facies predominantly of acid volcanic material (tuff, tuff-conglomerate, agglomerate, andesitic breccia, and tuffaceous sandstone). Predominantly volcanic facies lies east of a line from Lo-k'ou-t'ang (A-3) in SE Kiangsi to Lin-ch'uan (B-1) in eastern Kiangsi, however, not all Cretaceous redbeds east of this line are of volcanic facies. The two areas east of Lin-ch'uan are predominantly volcanic; area around Kuang-ch'ang (B-2) and area southeast of Hui-ch'ang (A-3) contain much volcanic material. Both types of Cretaceous redbeds are in places veined with calcite and quartz. Total thickness varies from about 3,000 to 4,500 feet in southeastern Kiangsi Province	Moderately to strongly folded, with NNE trend. Unit restricted to structural basins; dips are usually less than 45° but near-vertical dips not uncommon near basin margins. Many normal faults of moderate displacement, some small-magnitude thrusts. Rocks commonly fractured and jointed; locally sheared and brecciated.	Non-volcanic type usually forms rolling to moderately rugged hills with slopes generally less than 40% a few as steep as 100%. Local relief commonly 200 to 250 feet; maximum about 400 feet. Soil thin or absent; little or no vegetation. Steep slopes minutely eroded; harder sandstone layers in strong relief. Areas of conglomerate or sandstone form sugarloafs and other steep-sided forms similar to topography in the Tertiary redbeds. Interbedded-volcanic type forms topography similar to non-volcanic type, where coarse-grained pyroclastics are absent. Where coarse-grained pyroclastics are dominant, unit is very resistant, forming rocky, rugged hills with relief as great as 3,000 feet; average relief probably less than 1,000 feet.

a/ Names of towns followed by coordinate location. Example: Lin-ch'uan (B-1). East-west coordinates lettered A to F, north-south coordinates numbered 1 to 4.

(continued)

FUKIEN REGION (CHINA)

For reliability see Introduction and Reliability Index map inset on Geology map.
Summary report; some additional information available for more detailed studies in areas where index map shows good or excellent reliability.

Map Unit	Rock Types	Lithology	Structure	Topographic Expression
Jc JURASSIC COAL-BEARING SERIES AND TRIASSIC(?) SHALE	Moderately hard to hard sandstone, some shale and conglomerate.	Northern Fukien: Upper group of white, gray, and greenish hard sandstone beds, with layers of conglomerate and of reddish-brown, greenish-gray, and black shale; more than 3,300 feet thick. Lower group, 1,300-foot thickness of well-bedded sandstone interbedded with gray and black shale. Thin coal beds. Continental Jurassic. Eastern Kiangsi: Three groups of beds, of about equal thickness, totaling 2,300 to 2,600 feet. Upper group is shale with small amounts of sandstone; well developed NE of I-huang (B-1), probably unimportant elsewhere. Middle and lower groups are sandstone and shale beds; each group has basal conglomerate and thin coal beds. Non-marine Jurassic. Southeastern Kiangsi: In areas near Jui-chin (A-3), P'ing-shan (B-2), and Yan-keng (A-2), section consists of light gray feldspathic or argillaceous sandstone, red sandy shale, and red, green, or yellow shale. Thin coal beds at top. Probably Triassic.	Strongly folded in NE trend. Beds fractured, jointed, and faulted.	Northern Fukien: Hard sandstone forms high ridges. Lower rolling hills on shale. Valleys in shale are broad; in sandstone areas, narrow and discontinuous. Kiangsi: Low, rolling hills, locally moderately rugged. Relief commonly less than 300 feet; maximum about 600 feet.
Pzs MIDDLE AND UPPER PALEOZOIC SEDIMENTARY ROCKS	Hard sandstone, soft to hard shale, small amounts of slate, conglomerate, quartzite, and limestone.	These rocks may be divided into four groups. Uppermost Group: 1,100 to 1,300 feet of hard non-marine upper Permian quartz sandstone with some interbedded black shale and slate, and thin coal beds. Top beds of group generally more shaly. In northern Kwangtung, lower beds of group are hard quartzite. In Kiangsi, this group is thin (500 to 700 feet) or missing. Second Group: 400 to 500 feet of well-bedded gray or black lower Permian limestone with abundant flint nodules. In Kiangsi Province, this is underlain locally by 150 feet of massive, white, pure limestone. This group widely distributed but outcrops in small areas only, no single area being larger than a few square miles. Third Group: 500 to 650 feet of hard Carboniferous quartz sandstone interbedded with gray or black shale, and minor conglomerate. A few coal beds in Kiangsi Province. Basal quartz-pebble conglomerate in Fukien Province. These beds not exposed in Kwangtung Province. Lowermost Group: Hard quartz sandstone, quartzite, shale and slate, probably Devonian. In Fukien Province this group is made up of 650 feet of interbedded shale, quartzite, and slate, underlain by 1,000 feet of massive or thick-bedded flesh-colored hard quartzite with minor shale intercalations. In Kiangsi Province the group consists of hard quartzose sandstone, thick-bedded, hard, grayish-white quartzite and quartzite conglomerate, fine-grained micaceous sandstone, and some sandy shale. Thickness ranges from 650 feet at Yungfeng (A-1) to 1,650 feet near Hsia-chang (A-1) and 3,300 feet near Lo-k'ou-tang (A-3). This group not exposed in northern Kwangtung Province.	Strongly folded and faulted in NE trend. Dips are moderate to overturned. Strongly jointed and fractured; locally brecciated.	Forms moderately rugged to very rugged mountainous country. Local relief commonly a few hundred to over 3,000 feet in Fukien Province; somewhat less in Kwangtung, and commonly several hundred to 1,200 feet, rarely 2,500 feet in Kiangsi. Massive quartzite, probably Devonian, commonly forms rugged, cliffed hogback ridges of highest relief. In Kiangsi, the lower Permian limestone locally forms small isolated bare-rock pinnacles 100 to 200 feet high; the area north of Ao-shang and east of Hsia-chang (A-1) has this topography. Stream valleys broad in shaly parts of section, commonly constricted and discontinous in hard sandstone or quartzite.
pDps PRE-DEVONIAN PHYLLITE, SLATE, AND SCHIST	Phyllite and slate, some mica schist, small amounts of thin-bedded quartzite, thin-bedded sandstone, and conglomerate.	Fukien: Biotite schist with many quartz veins. Marble and quartzite at Hu-lu-shan (D-2). Thickness unknown. Probably pre-Cambrian. Kiangsi: Gray-green and yellow-green phyllite and slate, with small amounts of thin interbedded quartzite, and hard sandstone. Locally mica schist, as near Chin-ch'i (B-1) and around I-huang (B-1). Thickness more than 3,500 feet. Possibly pre-Cambrian to Silurian.	Strongly folded and faulted. Locally sheared.	Fukien: Moderately rugged to rugged mountainous country; local relief commonly 500 to 1,500 feet. Steep-sided ridges with slopes of 35 to 45%; ridge tops rounded. Slopes smooth; rock outcrops rare. Very small streams in canyons. Larger streams have flat-bottomed valleys, usually rather narrow but constricted by rocky ledges in only a few places. A few small landslides. Kiangsi: Varies from low, rolling hills to high, rugged, mountainous country. Along broad areas paralleling Kan Chiang(A-1), Hsu Chiang (B-1), and some of their larger tributaries, phyllite forms low rolling hills with local relief up to 250 feet. Between these areas it forms rugged topography with local relief commonly as much as 1,500 feet, maximum 2,100 feet. Schist areas slightly more rugged; maximum relief over 3,000 feet.
pKsm PRE-CRETACEOUS SEDIMENTARY AND METAMORPHIC ROCKS	Comprises undifferentiated map units Jc and Pzs in Fukien and Kwangtung Provinces. In Kiangsi Provinces the unit is predominantly Map Unit pDps and includes undifferentiated Jc and Pzs.	- - - - -	- - - - -	- - - - -
Gr GRANITIC ROCKS	Granite and granite gneiss; minor amounts of granodiorite, quartz diorite, and diorite; very minor amounts of granite pegmatite, diabase, and gabbro. May include some large areas of phyllite and mica schist.	Light-gray hornblende or biotite granite and red porphyritic granite, commonly with pronounced gneissic structure, occur as batholiths, stocks, and cupolas. Granite gneiss present along Fukien coast at Ssu-ming (D-4); probably predominant in map unit north and west of Chien-ou (D-1). Forms all of linear mass southwest of Chien-yang (D-1), and western half of broad mass along Fukien-Kiangsi boundary northeastward from Kuang-ch'ang (B-2). Large areas of phyllite and mica schist may be included with the granite-gneiss. Granodiorite, quartz diorite, and diorite found as stocks, dikes, and sills. Small patches and dikes of granite pegmatite in granite, particularly in SE Kiangsi tungsten district (see Mineral Resources map); small sills and dikes of diabase and gabbro. The rocks of this unit vary in age. The granite gneiss is possibly pre-Cambrian. The granite of Kiangsi and southern Fukien as far north as the area between Lung-yen and Ssu-ming (Amoy) is largely upper Jurassic. In the An-ch'i (D-3)a/ area and northward throughout Fukien, the granite intrudes the rhyolite series and is early Tertiary.	NE-trending lineation prominent over much of Fukien Region. Extensive large-displacement faulting probable. Much jointing and fracturing, particularly in granite-gneiss areas.	Fukien: Commonly underlies moderately rugged to rugged mountainous country with relief of 1,000 to 3,000 feet. Slopes commonly steep, but usually less than 60%. Many bare rocky slopes, extremely rough in detail; many very large subrounded boulders and boulder piles. Dissection may be intricate but ridge tops are characteristically somewhat rounded; all erosional features slightly less rugged than those on rhyolite. No evidence of erosion control by linear joint or fracture system. Granite gneiss or gneissic granite forms topography showing pronounced NE lineation. At Chin-men Tao (Quemoy Island), near Ssu-ming (D-4), bare, rocky steep hills show pronounced alignment of small fins of bare rock, and some parallelism of ridges. Eastern Kiangsi and a Few Small Areas in Fukien: Small granite masses are commonly eroded to low rolling hills with relief of 100 to 300 feet. Weathering may extend 30 feet or more below surface in valleys and on low hillsides. Weathered rock minutely dissected into badlands.

a/ Names of towns followed by coordinate location. Example: Lin-ch'uan (B-1). East-west coordinates lettered A to F, north-south coordinates numbered 1 to 4.

Prepared by U. S. Geological Survey
for Chief of Engineers, U. S. Army.

MINERAL RESOURCES

~~CONFIDENTIAL~~

FUKIEN REGION (CHINA)

CONVERSION GRAPH

Meters: 3,000 · 2,500 · 2,000 · 1,500 · 1,000 · 500 · 0

Feet: 10,000 · 9,000 · 8,000 · 7,000 · 6,000 · 5,000 · 4,000 · 3,000 · 2,000 · 1,000 · 0

EXPLANATION

- Main surfaced all-weather roads.
- Other roads; mostly unsurfaced, many poor in wet weather.
- Road destroyed in many places.
- Road probably destroyed in many places.
- Railroad.
- Railroad destroyed.

GLOSSARY

Ao	bay
Ch'i	stream
Chiang	river
Feng	mountain
Hai-kou	strait
Ho	river
Hsia	strait
Hsü	island
Lieh-tao	island group
Ling	mountain
Shan	island, mountain
Shui	river
Tao	island
Wan	bay

EXPLANATION

Reliability: Fair

Mineral Deposits Other than Coal

- × 1-5 Iron
- ♀ 6 Tungsten; minor deposit
- ♀ 7-11 Tungsten; major deposit
- ▮ 12-17 Lead, zinc, and silver.
- ⊖ 18 Molybdenum
- ▣ 19-20 Pyrite
- ■ 21-23 Alunite

Minor Deposits not Discussed in Table

- ♀ Tungsten
- ▲ Copper
- ⊘ Gold (placer)
- ◉ Coal Deposit
- ■ Pyrite.

Scale 1:1,000,000

10 5 0 10 20 30 40 50 60 70 80 90 100 Miles

10 5 0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 Kilometers

HEIGHTS IN METERS

Base adapted by A.M.S. and U.S.G.S. from A.M.S. 5301, 1:1,000,000, Sheets NG 50 and NG 51, 1944.

PREPARED BY U. S. GEOLOGICAL SURVEY FOR CHIEF OF ENGINEERS, U. S. ARMY

~~CONFIDENTIAL~~

52

Reliability: Good for Description of Deposits, Mining Methods and Treatment. Fair for Accessibility, Quality, Production, Potential Importance. Poor for Reserves (See table headings below).
Summary report; much additional information available for more detailed studies of some of the deposits.

INTRODUCTION

The Fukien Region contains scattered small deposits of non-coking bituminous and anthracite coal, mostly Jurassic and upper Paleozoic in age. Beds rarely exceed 3 feet in thickness, but locally are as thick as 11 feet (Chiacking deposit, No. 1 on Mineral Resources map). Except in the Chien-ou (Tsinning) District (No. 3), mining has been non-mechanized; all operations have been small.

Reserves of individual deposits are not large, but in the aggregate are considerable. Deposits studied in Fukien contain over 100,000,000 metric tons of anthracite and semi-anthracite. Kiangsi has 65,000,000 metric tons of reserves; mostly of poor quality. Kwangtung contains an unknown amount of semi-anthracite.

Peat of poor quality is mined on the coast south of Ssu-ming for local use.

Except along the coast and near coal deposits, wood or charcoal is the principal fuel. Normally the coastal region is supplied from northern China and Formosa. Except for a few districts close to water transportation, coal must move over porter trails or unimproved roads in mountainous country to rivers along which shipment by rafts or small boats is possible.

Data for 23 known deposits are summarized in the table below.

All information compiled directly from Chinese sources.

COAL

Province	Map No.	Location[a]	Coordinates[b]	Accessibility[c]	Description of Deposit	Quality	Reserves (metric tons)	Mining Methods and Treatment	Production (metric tons)	Potential Importance
FUKIEN	1	Chiaoking Shao-wu	C-1	Along Fu-t'un Ch'i shipment by river boat possible.	4 beds dipping about 25° SE; lowest 7.5 to 11.5 feet thick; others between 1 and 5 feet thick; all workable.	Anthracite; 3.7% ash; heating value 10,650 to 13,400 Btu. Friable, but makes good briquette.	8,000,000 for lowest bed; 15,000,000 for entire field (1929).	Non-mechanized; pits and shafts.	Approximately 100 tons a month.	Increase of reserve possible by prospecting; improvement in transportation needed for increased production.
	2	Hsiamei Ch'ung-an	C-1	In mountainous area; 1 to 3 mi from Ch'ung Ch'i down which coal can be rafted to Chien-yang, from there moved by river boat to Min-hou.	Bed 1.5 feet thick between sandstone and shale; dips 15° to 30°.	Anthracite; 19.6% ash, but only 1.86% volatile matter.	15,000,000 (1929)	Non-mechanized; pits and inclines.	Output small, for local consumption.	Unsuited for household use without washing to remove ash; bed too thin for large operation.
	3	Lishan Chien-ou	D-1	2 mi by light railroad to river port (town not named on map) on Tung Ch'i, where boat shipment is possible.	Bed 3 to 5 feet thick with shale roof and sandstone floor, dips 20° to 30°.	Semi-anthracite. Lump coal, high in ash (4.12% to 22.2%). Heating value 13,100 Btu.	5,000,000 (1929)	Semi-modern mining; shaft, mechanical hoisting. Ash reduced by washing.	Output small; district idle in 1927.	Depends on reduction of mining and transportation costs so that product can compete with wood fuel.
	4	Hungkaoshan Lung-yen	C-3	5 mi from Chang-p'ing where boat shipment is possible.	Probably single coal bed less than 1.5 feet thick, outcropping over considerable area in mountainous country.	Semi-anthracite to bituminous; brittle or powdery; low in sulphur (0.52% to 0.63%); volatile matter 10.35% to 14.05%; ash 7.55% to 16.3%.	Probably large.	Non-mechanized mining; pits and inclines.	Small, for local use.	Bed too thin for large operation.
	5	Waiyang and Supan Lung-yen	C-3	On navigable Chiu-lung Chiang.	One bed averages 1.5 feet thickness; has low dip.	Anthracite; ash about 9%; heating value 13,500 Btu.	3,040,000 (1933); calculated to depth of 650 feet.	Non-mechanized mining; pits and inclines.	Small, consumed locally.	Bed thin, but location good; possible additional reserves in unexplored area to SW.
	6	Paisha Lung-yen	C-3	In hilly country between 12 and 18 mi north of Lung-yen. A few miles from Chiu-lung Chiang.	One bed, 3 to 5 feet thick; has consistent dip of 35°.	Semi-anthracite; high in ash (16.3% to 20.5%), low in sulphur (0.72% to 1.03%); heating value 12,100 to 12,600 Btu.	5,800,000 (1933); calculated to depth of 125 feet.	Non-mechanized mining; pits and inclines.	Small; consumed in nearby town of Chang-p'ing.	Reduction of ash by washing would favor increased production.
	7	Kotenyu, Tachi, and Supang Lung-yen	C-3	Porter transportation to Lung-yen, about 8 mi to south.	One bed, 4 to 5 feet thick; dip averages 30°.	Semi-anthracite; ash 9.02% to 12.92%; heating value 13,150 Btu.	6,340,000 (1933); calculated to depth of 650 feet.	Not mined.	None.	Structure regular; suitable for small operation. Transportation difficult.
	8	Hsialao Lung-yen	C-3	Porter road to Lung-yen, 7 mi to south; from there, water transportation possible.	One bed, averages 3 feet in thickness; dips 20° to 40°.	Anthracite; 8.92% ash; heating value 13,500 Btu.	4,660,000 (1933); calculated to depth of 650 feet; possible extension in unexplored area to NE.	Not mined.	None.	Suitable for small operation.
	9	Tungshan Lung-yen	C-3	1 to 3 mi east of Lung-yen; hilly country. Water transportation at Lung-yen.	Coal-bearing series outcrops over 6 sq mi; single workable bed, 1.6 to 5.1 feet thick, dips 20° to 40°.	Anthracite; brittle and powdery; low in ash (4.20% to 7.11%) and in sulphur (0.79% to 1.41%); heating value 13,100 to 13,700 Btu.	13,770,000 (1933); calculated to depth of 650 feet.	Non-mechanized; pits and inclines.	180 tons a month in 1933; consumed locally.	Size of deposit and fair quality favor increased production.
	10	Lungmen Lung-yen	B-3	2.5 to 3.5 mi west of Lung-yen; possible shipment in river flowing across district.	Single workable bed 3 to 5.7 feet thick; dips 40°.	Anthracite, similar to that of No. 9.	3,340,000 (1933), calculated to depth of 650 feet. Drilling might establish additional reserves.	Non-mechanized; pits and inclines.	About 100 tons a month in 1933; consumed locally.	Increased production favored by location, regular structure, and possibility of additional reserves.
	11	Liuhuisheh Haichen	D-4	On coast; boat shipment available.	Horizontal layer of peat a few inches to 5 feet thick, resting on lava rock.	Moisture 5.15%; ash 33.05%.	Probably small.	Non-mechanized open pit.	Small, consumed locally.	Economic value doubtful.
KWANGTUNG	12	Mingshanchang Mei-hsien	B-4	Overland transportation over rugged country to Mei-hsien, 9 mi WNW.	Two beds, each 1.5 feet thick, outcrop in lower mountain slopes; dip 10° to 30°.	Semi-anthracite; ash 17.5% to 17.9%; heating value 10,463 to 10,587 Btu.	Unknown.	Non-mechanized mining; inclined shafts along strike of beds.	Unknown.	Thin beds and location unfavorable for development.
	13	Yangkungling Shihsing	B-4	Close to Mei-Chiang; boat shipment possible.	Number and thickness of coal beds unknown; coal-bearing series dips 30° to 40°.	Semi-anthracite; coal very friable; ash 18.6%.	Unknown.	Non-mechanized; mostly inclines.	13,900 tons in 1931.	Poor quality but suitable for household use; largely usable for lime-burning.
	14	Hengchin Mei-hsien	B-4	Water transportation on Mei-Chiang possible.	Two beds, each 1.5 feet thick.	Semi-anthracite; ash 7.6 to 15.3%; heating value 11,510 to 12,760 Btu.	Unknown.	Non-mechanized mining; inclined shafts along strike of beds.	9,000 tons in 1931.	Location favorable, but beds thin; chiefly used in lime-burning, and to a small extent for household use. Little possibility of further development.
KIANGSI	15	Tentien Yung-feng	A-2	29 mi NW to Yung-feng, by road.	One bed, 3 feet thick.	Anthracite; ash 35.1% to 51.9%.	25,000,000	Non-mechanized mining.	Small production; household use only.	Probably unimportant.
	16	Taiyuan Chi-shui	A-1	17 mi NW to Chi-an; overland transportation.	One bed, 3 feet thick.	Probably anthracite.	14,000,000	Non-mechanized mining.	No operation for many years.	Probably unimportant.
	17	Tinkiang Chi-shui	A-1	Overland transportation to Chi-shui about 13 mi to NW; at Chi-shui, water transportation on Kan Chiang.	No data.	Probably anthracite.	No data.	No data.	No data.	Probably unimportant.
	18	Heilung Chi-shui	A-1	Less than 2 mi to water transportation on Kan Chiang.	Two beds, each 2.5 feet thick.	Sub-bituminous; ash content 40%.	2,350,000	Non-mechanized mining.	Used locally in lime kiln.	Unimportant.
	19	Takengshan Chi-shui	A-1	Water transportation on Kan Chiang, about 9 mi to west.	Four beds; one 2.5 feet thick, another 3 feet thick.	Bituminous; ash 14.7% to 70%.	1,750,000	Non-mechanized mining.	Local use only.	Unimportant.
	20	Lohuchiao Feng-cheng	A-1	Close to water transportation.	Four beds, 1.5 to 5 feet thick.	No data.	10,000,000	Non-mechanized mining.	About 4,000 tons annually.	Local market in central Kiangsi Province.
	21	Fengpo T'sung-jen	A-2	5 mi to water transportation.	Three beds, each 1.5 feet thick; others a foot or less in thickness.	Bituminous; ash 41.6% to 54.3%.	9,750,000	Non-mechanized mining.	1,000 tons in 1940; has been worked by several companies for over 30 years.	Unimportant.
	22	Anyuan T'sung-jen	A-2	9 mi to water transportation.	Two beds, each a foot or less in thickness.	Bituminous; ash 2.5% to 46%.	3,180,000	Non-mechanized mining.	Small, for local use.	Unimportant.
	23	Yungshan I-huang	A-2	On I-huang Shui; boat transportation possible.	No data.	Probably bituminous.	No data.	No data.	No data.	No data.

a/ Reference (respectively) to name of deposit and to hsien (administrative district roughly equivalent to county in U.S.A.). Capital town of hsien, with same name, is usually shown on map; hsien boundaries not shown.
b/ East-west coordinates on Mineral Resources map lettered A to F, north-south coordinates numbered 1 to 4.
c/ Most distances taken from original Chinese sources; do not necessarily agree with this base map.

(continued)

MINERAL RESOURCES — FUKIEN REGION (CHINA)

Reliability: Good for Description of Deposits, Mining Methods and Treatment. Fair for Accessibility, Quality, Production, Potential Importance. Poor for Reserves. (See table headings below).
Summary report; much additional information available for more detailed studies of some of the deposits.

INTRODUCTION

The Fukien Region includes a part of the tungsten-producing district of Kiangsi Province, from which a large part of the American supply has been derived. The tungsten deposits are mined by primitive methods, but the concentration is carried on in modern plants. Until recently concentrates were shipped by air to the United States.

The only other mineral material produced in quantity is alum from deposits in southeastern Chekiang, which normally provides a large part of Chinese requirements.

Iron-ore deposits of potential importance are undeveloped, largely because of their inaccessibility. Crude native furnaces however produce a small amount of iron, chiefly from iron sands.

Other deposits including lead, zinc, silver, copper, molybdenum, gold, and pyrite have been mined on a small scale and some may be of potential importance.

Available data for deposits located on the Mineral Resources map are summarized in the table below.

Resource	Map Number	Location[a]	Coordinates[b]	Accessibility[c]	Description of Deposit	Quality	Reserves (Metric Tons)	Mining Methods and Treatment	Production (metric tons)	Potential Importance
IRON	1.	Loyang, Hua-an	C-3	About 30 mi north of Hua-an; water transportation at Hua-an on Chiu-lung Chiang.	Vein-like hematite deposit, in quartzite near granite contact. Dimensions 7,500 x 160 ft.	Averages over 45% iron.	12,800,000 (1933)	Can be mined by open cut.	None.	Fairly good grade but difficult accessibility.
	2.	Tsaoyang, Chang-p'ing	C-3	About 13 miles (in straight line) to Chang-p'ing. Difficult overland transportation.	Vein of magnetite between 325 and 650 ft long and 16 ft wide; sandstone walls.	Rich ore, contains around 60% iron; probably high in phosphorus.	400,000 (1933)	Underground mining necessary.	None.	Small reserves; difficult transportation.
	3.	Pantien, An-ch'i	C-3	About 30 mi NW of An-ch'i; difficult overland transportation, mostly over hilly and mountainous country.	Replacement bodies of hematite and small amount of limonite; form irregular pockets and lenses in sandstone. Of 8 known ore bodies, the largest is 650 x 426 x 130 ft, the smallest 65 x 65 x 16 ft.	Average 65% iron; low sulphur and phosphorus.	11,506,000 (1935)	Can be mined by open cut.	None.	High grade of ore and moderately large reserves; offset by relative inaccessibility.
	4.	Chenti, An-ch'i	C-3	Approximately 14 mi NW of An-ch'i.	Contact metamorphic deposits of hematite with some magnetite and limonite; along contact between granite and limestone. Five ore bodies in sheets dipping 10° to 20°; largest with dimensions 900 x 165 x 45 ft.	Single analysis indicates above 50% iron.	1,462,000 (1935)	Can be mined by open cut.	None.	High-grade ore, but inaccessible.
	5.	Suluan, An-ch'i	D-3	About 12 mi by trail and road from An-ch'i.	Contact metamorphic deposit of magnetite and hematite at contact between granite and limestone; ore body irregular in shape, roughly 950 ft long, up to 100 ft wide.	Single analysis indicates around 50%.	2,000,000	Can be mined by open cut.	None.	Difficult accessibility; value of ore considerably decreased by abundant pyrite.
TUNGSTEN	6.	Kwanheng, Mei-hsien	B-4	About 8 mi from nearest water transportation (on Shih-k'u Shui).	Ore in veins and stringers.	Unknown.	Unknown.	Non-mechanized mining.	80 tons concentrates produced between 1939 and 1943.	Unknown.
	7.	Siaolung, Tai-ho	A-2	Approximately 9 mi from water transportation on Kan Chiang.	22 known veins, aggregate width 23 ft. Veins between 900 and 1,650 ft long.	0.4% to 12% WO_3; average recovery 1.05%.	108,000 WO_3 (1939)	Pits and tunnels; hand-sorting and jigging.	Present annual production between 240 and 300 tons concentrates; in 1938, 540 tons concentrates.	Production increase possible; difficult transportation.
	8.	Huameiao, Ning-tu	A-2	About 30 mi east of collecting station at Hsing-kuo. Boat transportation.	34 known veins in sandstone; also placer deposits.	Slightly less than 2% WO_3.	No data available.	Chiefly placer mining; hand-sorting and jigging.	3,541 tons concentrates, mostly from placers (July 1941 to Sept 1943).	Discovered 1941; probably important potential producer.
	9.	Liaokeng, Ning-tu	A-2	6 mi overland transportation to Ning-tu; from there by boat to Yu-tu.	2 veins in granite; also rich placer deposits.	High grade.	No data available.	Pits and tunnels; hand-sorting and jigging; little work done.	In 1943, at rate of 240 tons concentrates annually.	New discovery (1941).
	10.	Shangping, Yu-tu	A-3	About 19 mi south of Yu-tu	50 discontinuous veins in slate and sandstone; veins 0.45 to 2.2 ft wide.	1.5% to 2% WO_3	47,040 WO_3 (1942).	Adits on slope of mountains at different levels.	Began in 1929; large production since 1936.	Probable increase in production.
	11.	Pankushan, Anyuan	A-3	Less than 2 mi from water transportation; reached by trail.	26 closely spaced veins of wolframite, bismuthinite, and bismuth carbonate in sandstone; veins between 1.6 and 11.5 ft wide form zone 3,600 ft long and 820 ft wide.	Ore pockety, high grade in part; average bismuth content 0.1%.	225,000 WO_3; 5,000 Bi.	Shafts to 260-ft level; difficulty in handling mine water.	Began 1922; 288 tons concentrates in 1942; decreasing on account of water	Adequate pumping equipment would probably increase production.
LEAD, ZINC AND SILVER	12.	Milowan, Kuang-tse	C-1	30 mi trail transportation SW to Kuang-tse over mountainous country (not in direct line).	Silver-bearing galena, with fluorite and quartz; discontinuous narrow veins in granite.	Good; 30% lead; 48 oz/ton silver.	No data.	Non-mechanized mining; pits and inclines.	About 0.12 tons ore per day in 1929.	Probably worth systematic prospecting.
	13.	Hoyuang, P'u-ch'eng	D-1	Trail transportation 22 mi NW to P'u-ch'eng, where raft transportation is available.	Galena vein in banded granitic rock.	No data.	No data.	Non-mechanized mining.	Small, operated only in 1912 and 1913.	Probably exhausted.
	14.	Shitzelung, Cheng-ho	D-1	13 mi north of Cheng-ho; 50 mi trail transportation to Chien-ou (Tsinning) where water transportation is available.	Sphalerite and galena.	No data.	No data.	Non-mechanized mining.	Small; operated in 1916.	Deposit relatively inaccessible; probably poor-quality ore and small reserve.
	15.	Sunchiayang, Cheng-ho	E-1	About 18 mi SE of Cheng-ho. 48 mi trail transportation SW to Chien-ou (Tsinning) where water transportation is available.	Galena vein in porphyry; 1 ft thick.	No data.	No data.	Non-mechanized mining.	No data; deposit now abandoned.	Deposit relatively inaccessible; probably poor quality and small reserve.
	16.	Fuchi, Nan-p'ing	D-2	About 8 mi to Min Chiang, on which boat shipment is possible.	Silver-bearing galena vein.	Poor.	No data.	Non-mechanized mining.	No data; deposit now abandoned.	Probably not important.

[a] Reference (respectively) to name of deposit and to hsien (administrative district roughly equivalent to county in U. S. A.). Capital town of hsien, with same name, is usually shown on map; hsien boundaries not shown.
[b] East-west coordinates on Mineral Resources map lettered A to F, north-south coordinates numbered 1 to 4.
[c] Most distances taken from original Chinese sources; do not necessarily agree with this base map.

(continued)

FUKIEN REGION (CHINA)

MINERAL RESOURCES

Reliability: Good for Description of Deposits, Mining Methods and Treatment. Fair for Accessibility, Quality, Production, Potential Importance. Poor for Reserves. (See table headings below).
Summary report; much additional information available for more detailed studies of some of the deposits.

Resource	Map Number	Location[a]	Coordinates[b]	Accessibility[c]	Description of Deposit	Quality	Reserves (Metric Tons)	Mining Methods and Treatment	Production (metric tons)	Potential Importance
LEAD, ZINC AND SILVER (continued)	17.	Chienkeng, Yung-ch'un	C-3	Overland transportation 22 mi SW to Hua-an; from Hua-an water transportation on Chiu-lung Chiang.	Galena and sphalerite veins in limestone.	No data.	No data.	No data.	No data.	Unknown.
MOLYBDENUM	18.	Pupitsun, Yung-t'ai	D-3	5 mi from river transportation to coast.	Molybdenite in thin, discontinuous pegmatite and quartz veins; also in veinlets and disseminations in granite.	High grade, probably about 3% Mo.	Probably moderate.	Non-mechanized; pits and inclines.	26 tons ore from 1913 to 1915.	High grade and relatively convenient location may warrant further development.
PYRITE	19.	Fayuanchiushan, Ch'ing-t'ien	F-1	21 mi by porter road NE to Ch'ing-t'ien. Water transportation on Ou Chiang.	Pyrite vein in tuff beds; 1.5 ft wide, 100 ft long.	Good; 12% to 80% pyrite, average 40%.	6,090 (1934).	Non-mechanized; pits and inclines.	Small; no production since 1934.	Ore at shallow depth probably exhausted.
	20.	Laokuoshan, Ch'ing-t'ien	E-1	43 mi by porter road north to Ch'ing-t'ien.	Pyrite vein in tuff beds; 16.5 ft wide, 65 ft long.	Good; 30% to 70% pyrite.	750 (1934)	Non-mechanized; pits and inclines.	Small.	Continued production probable.
ALUNITE	21.	Taihu, Ping-yang	F-1	Close to river (not named on map) on which small-boat transportation to coast is possible.	Alunite in altered volcanic rocks.	Averages about 20% Al_2O_3.	Data incomplete; reserves probably less than for Fanshan deposit (No. 42).	Non-mechanized; open quarry and pits; alunite burned in kilns and dissolved in water; alum obtained by crystallization.	Between 2,000 and 3,000 tons alum yearly.	Prospects favorable; moderately large reserves and high-grade ore.
	22.	Fanshan, P'ing-yang	F-1	9 mi overland transportation to coast.	Alunite in altered volcanic rocks; productive zone approximately 600 ft thick, 3.4 mi long.	Average ore contains 26% Al_2O_3.	255,234,000 tons alum.	Non-mechanized; open quarry and pits. Refinement process same as for deposit No. 41.	Average 15,000 tons annually.	High grade, large reserves indicate great potentialities.
	23.	Fu-ting, Fu-ting	F-1	Less than 6 mi from coast.	Alunite beds in volcanic rock; extension of Fanshan deposit, No. 42.	Good; similar to deposit No. 42.	Smaller than deposit No. 42.	Non-mechanized; open cut and pits.	Between 1,000 and 2,000 tons annually	Increased production possible.

[a]/Reference (respectively) to name of deposit and to hsien (administrative district roughly equivalent to county in U.S.A.). Capital town of hsien, with same name, is usually shown on map; hsien boundaries not shown.
[b]/East-west coordinates on Mineral Resources map lettered A to F, north-south coordinates numbered 1 to 4.
[c]/Most distances taken from original Chinese sources; do not necessarily agree with this base map.

Prepared by U. S. Geological Survey
for Chief of Engineers, U. S. Army

CLIMATE

FUKIEN REGION (CHINA)

Sources: Army Air Forces, Headquarters, Weather Information Branch, General Climatic Information Guide nos. 106 and 144, 1944.
Hurlbut, F., The Climate of Fukien Province: Fukien Christian Univ. Nat. Hist. Soc. Proc., vol. 3, pp. 39-45, 1930.

The climate of the Fukien region is warm humid temperate in the north and humid subtropical in the south. In the mountains of Fukien Province and the hill lands of Kiangsi Province, the climate is subject to greater variations than in the coastal belt.

The following is a brief summary of climatic information. For detailed studies of the climate, other intelligence sources should be consulted.

Temperatures

(All figures represent degrees F.)

At the coast, the mean monthly temperatures range only from about 55° to 85°. The mean maximum and minimum ranges for the seasons are as follows: winter, 50° to 65°; spring, 55° to 80°; summer, 70° to 90°; autumn, 60° to 85°. Minimum temperatures, below 40°, occur about one day a month in winter. In summer, temperatures above 90° are recorded frequently.

In the interior, temperature ranges are greater than at the coast. In summer, temperatures are high, probably above 90°, for considerable periods of time. In winter, temperatures are often below freezing; the lowest ones probably occur in the mountains at the boundary between Fukien and Kiangsi Provinces.

Precipitation

Total precipitation is about 40 to 80 inches annually. Precipitation is generally higher in the interior than at the coast. The heaviest rains occur in late spring and summer, mainly as thunderstorms. A late summer peak is reached in the coastal area, owing to torrential downpours brought by typhoons. The driest season, with only 2 to 3 inches of rain per month, lasts from October to February.

Snow is rare near the coast; it is more common in the high mountains of the interior and snow cover remains on the ground during the winter months.

Winds

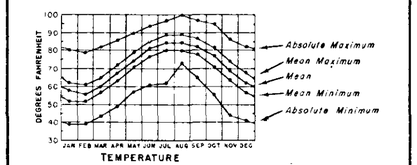
Northeast and north winds are predominant at all times of the year in the Min-hou (Foochow) area and to the north. At Min-hou (Foochow), westerly winds are also common in all seasons. Toward the south, in the Ssu-ming (Amoy) area, northeast and north winds (monsoons) are important in winter, but in spring and summer, south and southeast winds (monsoons) prevail. Typhoons occur during the late summer in the Min-hou area and north.

Humidity

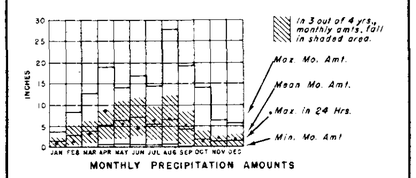
The humidity is high during all seasons except autumn. It tends to intensify the physical discomfort of the winter cold and summer heat.

Data for Min-hou and Ssu-ming

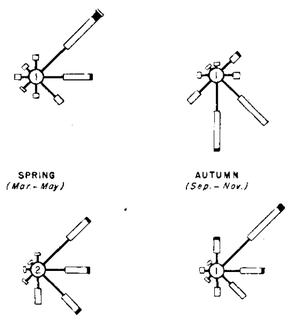
The following diagrams summarize data on precipitation, temperature, and winds for the Min-hou and Ssu-ming areas. They are copied from General Climatic Inf. Guides nos. 106 and 144, U. S. Army Air Forces, Weather Information Branch.

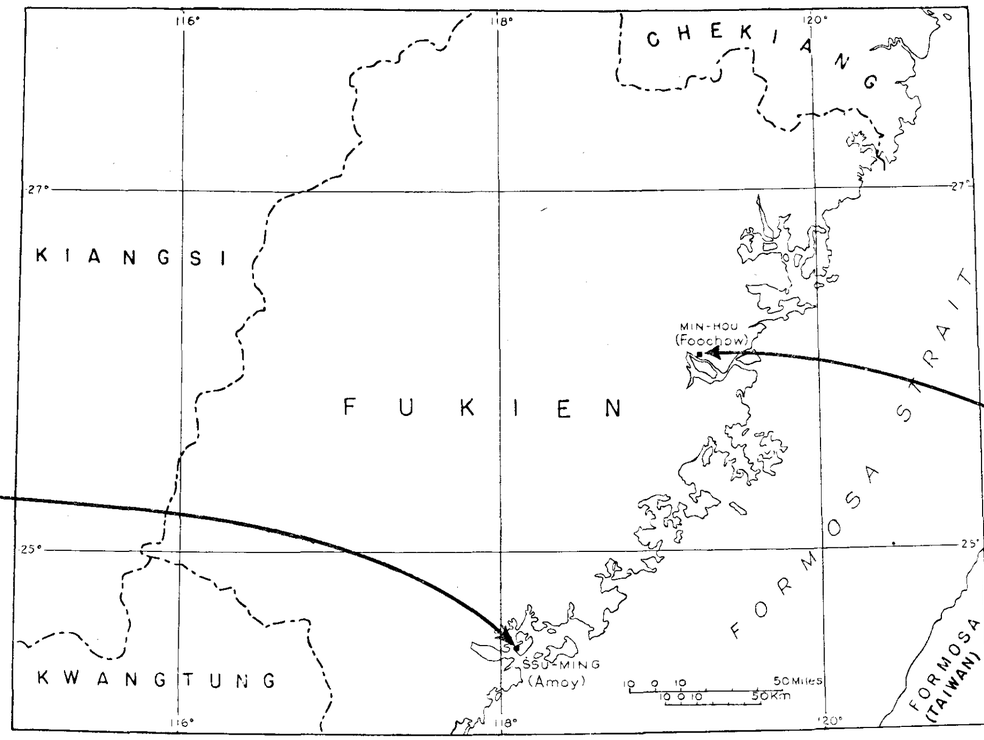


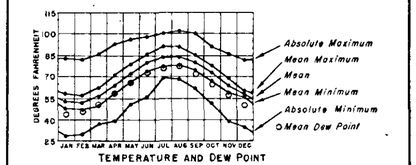
TEMPERATURE



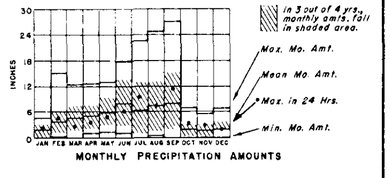
MONTHLY PRECIPITATION AMOUNTS



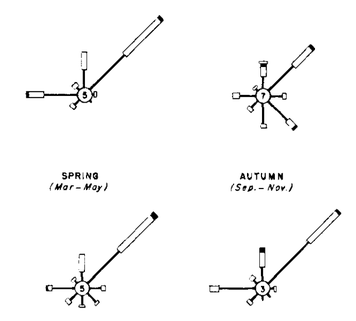


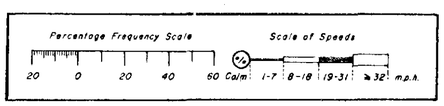


TEMPERATURE AND DEW POINT



MONTHLY PRECIPITATION AMOUNTS





PREPARED BY U. S. GEOLOGICAL SURVEY
FOR
CHIEF OF ENGINEERS, U. S. ARMY