The Engineering Geologist

THE GEOLOGICAL SOCIETY OF AMERICA

NEWSLETTER OF THE ENGINEERING GEOLOGY DIVISION OF THE GEOLOGICAL SOCIETY OF AMERICA

Volume 16, Number 2 May 1981

Geotechnical Research at the Iowa Geological Survey

Many of you are familiar with the Iowa Geological Survey, principally through our services and research in the areas of water and mineral resources and waste-disposal problems. The Survey has developed over the past 5 years a regional geotechnical research program in conjunction with engineers, architects, planners, and other government agencies. The aims of this ongoing program are to investigate specific geotechnical problems and to compile geotechnical data on a regional or state-wide basis, particularly as they relate to regional geologic materials and history.

The aims of the research, data, and reports are: (1) to provide a quanitiative evaluation of the engineering properties of geologically correlateable materials and soil-mapping units; and (2) to provide a geologic framework from which to understand the detailed distribution and origin of different materials and their attendant properties. The data, although quantitative, is "Not for Design Purposes." Nothing can replace on-site inspection for design purposes. However, research indicates that materials of similar geologic origin and history have a surprisingly narrow and predictable range of properties over their region of occurrence. Consequently, with an understanding of the geology of a particular site, it is hoped that the data can be used to give a preliminary estimation of the geotechnical properties of the materials at a site, problems that might be encountered, and the type of sampling and testing program most suitable for the materials likely to be present. Likewise, the program is designed to provide data which hopefully can be used for alternative site evaluation or comparison between different potential sites.

The present program to date can be subdivided into two categories:

1. Studies which quantify geotechnical properties in relation to soil series or soil-mapping units, as used in modern Iowa Cooperative Soil Survey-U.S.D.A. Soil Conservation Service county soil survey reports. This program has great utility since: (a) the soil-mapping units are differentiated on bases that are also important geotechnically; (b) the soil-mapping units have consistent properties regionally; and (c) about 60% of Iowa now has modern soil surveys, and the remaining mapping will be completed by the late 1980s.
2. Studies which analyze geotechnical properties in relation to regional geologic units. Again, the physical properties used to differentiate geologic units, and their geologic history, may also be important geotechnically.

The first category of studies includes data compilation by soil series on such things as highway engineering properties (Atterberg Limits, classification, and Proctor density) and the quantification of shrink-swell potential as related to soil texture. These studies are undertaken in cooperative with the Iowa Cooperative Soil Survey. Other related studies include the study of percolation rates and general suitability of different soil series for home sewage disposal.

The second category of studies includes ongoing research on such topics as: (1) hydrologic properties of unconsolidated materials; (2) the consolidation characteristics of the various glacial till deposits; and (3) shear strength and collapsibility of loess.

Two other major projects are currently in progress. First is a map set of the Geologic Hazards of Iowa. These maps, plus text, will outline potential geologic hazards of general geotechnical interest, including subsurface mined-out areas, karst regions, shrinking and swelling soils, expensive shales, and collapsible loess, and so on. A second major project underway is the Engineering Geologic Mapping of the Des Moines Glacial Lobe area in the north-central part of the state. Landforms on the Des Moines Glacial Lobe are unique in that they preserve some of the original forms left by the former glacier. Our research indicates that similar landforms are composed of comparable material sequences. Using available color infrared photography, detailed landform-sediment sequence mapping can be done. This mapping is being integrated with field observations and laboratory data on particle size, shear strength, unit weight, consolidation tests, and so on, to determine the geotechnical properties of the different material-landform sequences found in the Des Moines glacial lobe area.

In Memoriam

Secretary General

Dr. Richard Wolters

International Association of Engineering Geology

"Chevalier de l'Ordre National du Merite"

Born: May 1, 1921

Died: March 7, 1981

Earthquake-generated landslides, 1971 San Fernando earthquake

Dr. Bruce Clark and Dr. Beach Leighton of Leighton & Associates studied slope failures generated by the 1971 San Fernando earthquake under the National Earthquake Hazards Reduction Program. The failures were of two principal types: shallow soil slips involving weathered soils or colluvium, and rock falls or rock slides from steep exposed bedrock cliffs. The soil slips have been nearly obliterated by recent rains, but many bedrock failures appear little changed from their initial configuration and provide considerable insight into both their mode of failure and the hazard they represent.

The bedrock failures occurred from in situ loss of cohesion during the shaking process. Although the sites are characterized by a very steep headwall face, there is no evidence of either toppling or significant sliding along a rupture surface. Failure appears to be the result of heterogeneous motion of blocks during the earthquake itself. Existing joints widened and extended, literally shaking the slope apart. The most common rock types were conglomerates in the sedimentary sequence and blocky jointed gneisses and granite in the basement complex. Most failures occurred on anti-dip slopes where bedding was not a factor. Joints were probably present before the earthquake but were discontinuous enough to allow large steep slopes to remain stable under static conditions. The post-earthquake slopes appear similar to the pre-earthquake slopes; previous failures have not eliminated future hazards.

New dynamic finite element models developed by Dr. Clark using a typical cross-section of the failed slope indicate that the slope geometry plays an important role in concentrating earthquake-related activity near the cliff face. The face shows a concentration of as much as a factor of two in maximum displacement during the earthquake.

Application of well-logging techniques to coal exploration and mine design in Nigeria

Kola Fapohunda & Tunde Adegbesan, Engineering Geologists, Well-logging & Engineering Unit, National Steel Council, Kaduna

Exploration for coking coal, a vital raw material for the establishment of a blast furnace steel plant in Nigeria started in earnest in late 1971. Based on previous geologic information, exploratory activities which commenced in Afuze (Bendel State) moved to Lafia area of Plateau State where Senonian bituminous rank coal was discovered.

Since coal deposits invariably occur within sedimentary formations, an appreciable core recovery is nearly impossible, resulting occasionally in an incomplete documentation of lithology.

To obtain supplemental lithologic information, borehole geophysical logging has found widespread application. For this purpose, a series of measurements including natural radioactivity, dispersed gamma radiation or density, electrical resistivity and inclination are routinely carried out. The interpretation of such data collected has generally been based on theoretical methods.

While apparent resistivity and radioactive logging curves were employed as the main parameters for rock identification, the mono-electrode logging found profound use in the recognition of sharp and gradational coal boundaries.

From knowledge gained in previous investigations, various parameters have been employed in the identification of coal seams: These include high apparent resistivity values, distinct depressions on mono-electrode logs, low gamma radiation intensity and high dispersed gamma peaks.

Furthermore, the roof and floor measures of seams were distinguished by minimal and maximal gradient values of lateral curves. The delimitation of the contact of layers was based on marked-out transition points from gentle to steep lift and drop of curves on normal and mono-electrode current logs respectively.

Sidewall shooting of seams is frequently carried out at convenient intervals of about 10 cm to provide samples when unavailable from drilling and inevitably to confirm the accuracy of interpretation; thus making this technique an essential tool in the investigation and interpretation of new geologic environs.

The applicability of borehole logging parameters employed and interpretational methods was confirmed through other geologic activities including shaft-sinking operations and pilot mining.

To estimate the rate of influx of groundwater into the proposed mine, mud resistivity logging has become of crucial importance. Moreover, the caliper has been utilized successfully not only for the identification of rock formations but more importantly for the stratigraphic correlation of discontinuities such as joints, fractures and other structural openings within rock bodies.

Regrettably, the application of some recent methods of neutron and acoustic logging for the determination of ash and natural moisture content were impossible as these tools are not available locally on the logging equipment. Nevertheless, well log curves have been interpreted for the determination of depth, structures and thickness of coal occurrences which makes the techniques an invaluable geoscientific tool in such exploratory activities.

TWO NEW PROFESSIONAL GROUPS FORMED

The International Mine Water Association (IMWA), has been established with the following main objectives:

1. To improve exploitation of mineral deposits consistent with the desirable standards of safety against water hazards.
2. To increase protection of the environment against the impact of mine drainage and related activities.
3. To improve the utilization of mine waters.
4. To improve technology and economy of mine drainage control operations.
5. To create a forum for international exchange of information concerning the latest developments in the field of mine water problems.

INTERNATIONAL MINE WATER ASSOCIATION
Secretary:
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An International Cement Microscopy Association was formed recently in Dallas, Texas. The objective of this association is the application of the various types of microscopic techniques to practical use in analysing cement raw materials, clinker, cement, and concrete. The ultimate goal of this effort is better quality control, improved production, and energy conservation.

The chairman of the International Cement Microscopy Association is Walter W. Rowe, General Portland Cement, Inc., Dallas, Texas.

Geological Hazards of Natural Gas

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"Natural gas" has been defined, and is usually thought of as a "natural mixture of gaseous hydrocarbons." Such a concept probably is somewhat narrow. For example, carbon dioxide, hydrogen sulfide, and other gases of volcanic and fumarolic origin, gases of our atmosphere, or gases dissolved in natural waters and entrapped in rocks and sediments are by all means as "natural" as gaseous hydrocarbons. The following discussion, however, will be limited only to the usual definition of "natural gas."

Spontaneous ignition of marsh gas has been known and has aroused superstitions probably since prehistoric times. In ancient times powerful and bloody cults of fire worshippers (pyrolatry) inhabited areas of intense seepages of natural gas that were associated with petroleum deposits.

Natural gas at the present time is one of the key energy sources of modern civilization. Available reserves are being rapidly depleted and natural "rejuvenation" (for example "marsh gas") cannot compete with usage. Probably the most critical "geologic-economic hazard" associated with natural gas at the present time is the rapid depletion of available deposits.

Spontaneous or man-caused explosions of natural gases are a widely recognized geologic hazard related to their occurrence. Such explosions are particularly dangerous in a closed space, for example in underground workings. Explosions of methane in coal mines are well known and well publicized. Similar explosions, however, have also been recorded in hydroelectric and other tunnels and excavations. A well publicized failure of this type was the spontaneous explosion of methane in two 14.2-m-diameter diversion tunnels at the Furnas Dam in Brazil. Similar explosions were recorded also in the diversion tunnel at Akosombo Dam on the Volta River, at El Colegio Scheme in Columbia, in Switzerland, in Rumania and elsewhere. The original source of methane in these cases ranged from bituminous rocks to methane liberated in reservoirs from decaying vegetation. Meticulous monitoring, good ventilation, and alertness of personnel are probably the key factors in the prevention of such explosions.

Due to the relative mobility of natural gas, gas explosions may occur at a distance from main deposits and may take place in rock types genetically unrelated to the gas. Occurrence of methane-bearing gases in metamorphic and igneous rocks 5-15 miles away from sedimentary basins has been reported, for example, in the Klamath Mountains in northern California.

Genetically similar accumulations of methane are associated with sanitary landfills. Decay of fill in a manmade island on the St. Lawrence River in Montreal, Canada, resulted in the development of several gas seeps and spontaneous ignition of the gas. Several high-rise buildings in Toronto, Canada, built on fill are surrounded by relief wells constructed in order to prevent accumulation and explosions of methane. On the other hand, a potential possibility of new sources of the gas is provided by the generation of methane in waste disposal areas which are now under construction in different countries.

Geochemical hazards of natural gas are relatively unknown except for direct poisoning and suffocation but could be of significant importance. For example, methane is usually genetically associated with hydrogen sulfide, probably being formed by bacterial activity involving methane and the reduction of gypsum which is frequently present in sedimentary deposits. Hydrogen sulfide is definitely a poisonous gas. Equally undesirable are some chemical reactions caused by its presence. For example, black discoloration of soils by iron sulfides is common around leaks from underground gas pipes. These sulfides are deposited by a reaction between hydrogen sulfide and the iron oxide pigment in soils. Similar reactions between hydrogen sulfide and surrounding rocks were reported at some natural gas seeps in California's San Joaquin Valley. Here the oxidation of hydrogen sulfide, marcasite, pyrite, and other iron sulfides (black pigments) in excavations created native sulfur, sulfuric acid, gypsum, alunite, jarosite, and other sulfates. The pH values of the sediments became very low, with some samples having a pH of 0.5. Such low pH values are detrimental to organic life, concrete, steel, and other metals. Organic tissues were charcoaled by contact with such deposits and no vegetation grew here for several years after excavation. Toxic soluble aluminum ions created by decomposition of fine-grained alumosilicates by sulfuric acid in such acidic areas are an additional health hazard.

Associated with seepages of natural gas is colloidal iron sulfate pigment whose effect on the mechanical-physical-engineering properties of soils is also unknown. Shear strength, plasticity, and other properties of such black soils may be undesirably affected and may differ from the parent material. Such changes in natural or borrowed materials at construction sites can lead to various slope instabilities such as sliding, cracking, etc.

The ideas expressed in this paper are those of the authors and may not represent the official views of the Water and Power Resources Service.

EDITOR'S CORNER

1. By now most of you are aware of the "new look" of this issue of The Engineering Geologist. We expect to save a good deal of the publication costs of the Newsletter by typing the camera-ready copy with the kind assistance of the New York State Geological Survey. By preparing our own copy, the Division hopes to continue to put the Newsletter out four times a year at its present size. Authors of longer feature articles can help us out by contacting your editor for typing guidelines and submitting camera ready copy themselves.

2. Several comments have been received regarding Charlie Baskerville's article on the trials and tribulations of doing field work in the "Big Apple" (New York City). We would like to see other EGD members share the personal side of their engineering geology projects through the Newsletter.

3. You'll note that there is no Case-in-Point in this issue. That's because Chris Mathewson hasn't received any for publication. Let's not let this informative series die. Send your Case-in-Point contribution to:

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Recommended guidelines for preparing engineering geologic reports

The following general guidelines are issued by the California Division of Mines and Geology and are reprinted here as an aid to our members. Copies of this and other similar guides (CDMG Notes) are available by writing:

California Division of Mines & Geology
P.O. Box 2980
Sacramento, CA 95812

I. Geologic mapping

A. Each report must be a product of independent geologic mapping of the subject area at an appropriate scale and in sufficient detail to yield a maximum return of pertinent data. In connection with this objective, it may be necessary for the geologist to extend his mapping into adjacent areas.

B. All mapping should be done on a base with satisfactory horizontal and vertical control--in general a detailed topographic map. The nature and source of the base map should be specifically indicated. For sub-divisions, the base map should be the same as that to be used for the tentative map or grading plan.

C. Mapping by the geologist should reflect careful attention to the lithology, structural elements, and three-dimensional distribution of the earth materials exposed or inferred within the area. In most hillside areas these materials will include both bedrock and surficial deposits. A clear distinction should be made between observed and inferred features and relationships.

D. A detailed large-scale map normally will be required for a report on a tract, as well as for a report on a smaller area in which the geologic relationships are not simple.

E. Where three-dimensional relationships are significant but cannot be described satisfactorily in words along, the report should be accompanied by one or more appropriately positioned structure sections.

F. The locations of test holes and other specific sources of subsurface information should be indicated in the text of the report or, better, on the map and any sections that are submitted with the report.

II. General information

Each report should include definite statements concerning the following matters:

A. Location and size of subject area, and its general setting with respect to major geographic features.

B. Who did the geologic mapping upon which the report is based, and when the mapping was done.

C. Any other kinds of investigations made by the geologist and, where pertinent, reasons for doing such work.

D. Topography and drainage in the subject area.

E. Abundance, distribution and general nature of exposures of earth materials within the area.

F. Nature and source of available subface information. Suitable explanations should provide any technical reviewer with the means for assessing the probable reliability of such data. (Sub-surface relationships can be variously determined or inferred, for example, by projection of surface features from adjacent areas, by the use of test-hole logs, and by interpretation of geophysical data, and it is evident that different sources of such information can differ markedly from one another in degree of detail and reliability according to the method used).

III. Geologic descriptions

The report should contain brief but complete descriptions of all natural materials and structural features recognized or inferred within the subject area. Where interpretations are added to the recording of direct observations, the bases for such interpretations should be clearly stated.

The following check list may be useful as a general, though not necessarily complete, guide for descriptions:

A. Bedrock--igneous, sedimentary, metamorphic types.

1. Identification as to rock type (e.g., granite, silty sandstone, mica schist).
2. Relative age, and, where possible, correlation with named formations (e.g.; Rincon formation, Vaqueros sandstone).
3. Distribution.
4. Dimension features (e.g.; thickness, outcrop breadth, vertical extent).
5. Physical characteristics (e.g.; color, grain size, nature of stratification, foliation, or schistosity, hardness, coherence).
6. Special physical or chemical features (e.g.; calcareous or siliceous cement, concretions, mineral deposits, alteration other than weathering).
7. Distribution and extent of weather zones; significant differences between fresh and weathered rock.
8. Response to natural surface and near-surface processes (e.g.; raveling, gullying, mass movement).

B. Structural features--stratification, foliation, schistosity, folds, zones of contortion or crushing, joints, shear zones, faults, etc.

1. Occurrence and distribution.
2. Dimensional characteristics.
3. Orientation, and shifts in orientation.
4. Relative ages (where pertinent).
5. Special effects upon the bedrock. (Describe the conditions of planar surfaces).
6. Specific features of faults (e.g.; zones of gouge and breccia, nature of offsets, timing of movements); are faults active in either the geological sense or the historical sense?

C. Surficial (unconsolidated) deposits--artificial (manmade) fill, topsoil, stream-laid alluvium, beach sands and gravels, residual debris, lake and pond sediments, swamp accumulations, dune sands, marine and nonmarine terrace deposits, talus accumulations, creep and slope wash materials, various kinds of slump and slide debris, etc.

1. Distribution, occurrence, and relative age, relationships with present topography.
2. Identification of materials as to general type.
3. Dimensional characteristics (e.g.; thickness, variations in thickness, shape).
4. Surface expression and correlation with features such as terraces, dunes, undrained depressions, anomalous proturberances.
5. Physical or chemical features (e.g.; moisture content, mineral deposits, content of expansible clay minerals, alteration, cracks and fissures, fractures.
6. Physical characteristics (e.g.; color, grain size, hardness, compactness, coherence, cementation).
7. Distribution and extent of weathered zones; significant differences between fresh and weathered material.
8. Response to natural surface and near-surface processes (e.g.; raveling, gullying, subsidence, creep, slope-washing, slumping and sliding).

D. Drainage--surface water and groundwater.

1. Distribution and occurrence (e.g.; streams, ponds, swamps, springs, seeps, subsurface basins).
2. Relations to topography.
3. Relations to geologic features (e.g.; previous strata, fractures, faults).
4. Sources and permanence.
5. Variations in amounts of water (e.g.; intermittent springs and seeps, floods).
6. Evidence for earlier occurrence of water at localities now dry (e.g.; vegetation, mineral deposits, historic records).
7. The effect of water on the properties of the in-place materials.

E. Features of special significance (if not already included in foregoing descriptions).

1. Features representing accelerated erosion (e.g.; cliff reentrants, badlands, advancing gully heads).
2. Features indicating subsidence of settlement (e.g.; fissures, scarplets, offset reference features, historic records and measurements).
3. Features indicating creep (e.g.; fissures, scarplets, distinctive patterns of cracks and/or vegetation, topographic bulges, displaced or tilted reference features, historic records and measurements.
4. Slump and slide masses in bedrock and/or surficial deposits; distribution, geometric characteristics, correlation with topographic and geologic features, age and rates of movement.
5. Deposits related to recent floods (e.g.; talus aprons, debris ridges, canyon-bottom trash).
6. Active faults and their recent effects upon topography and drainage.

IV. The bearing of geologic factors upon the intended land use

Trestment of this general topic, whether presented as a separate section or integrated in some manner with the geologic descriptions, normally constitutes the principal contribution of the report. It involves both (1) the effects of geologic features upon the proposed grading, construction, and land use, and (2) the effects of these proposed modifications upon future geological processes in the area.

The following check list includes the topics that ordinarily should be considered in submitting discussion, conclusions, and recommendations in the geologic reports.

A. General compatibility of natural features with proposed land use: Is it basically reasonable to develop the subject area?

1. Topography.
2. Lateral stability of earth materials.
3. Problems caused by features or conditions in adjacent properties.
5. Other general problems.

B. Proposed cuts.

1. Prediction of what materisls and structural features will be encountered.
2. Prediction of stability bssed on geologic factors.
3. Problems of excavation (e.g.; unusually hard or massive rock, excessive flow of groundwater).
4. Recommendations for reorientation or re-positioning of cuts, reduction of cut slopes, development of compound cut slopes, special stripping above daylight lines, buttressing, protection against erosion, handling of seepage water, setbacks for structures above cuts, etc.

C. Proposed masses of fill.

1. General evaluation of planning with respect to canyon-filling and sidehill masses of fill.
2. Comment on suitability of existing natural materials for fill.
3. Recommendations for positioning of fill masses, provision for underdrainage, buttressing, special protection against erosion.

D. Recommendations for subsurface testing and exploration.

1. Cuts and test holes needed for additional geologic information.
2. Program of subsurface exploration and testing, based upon geologic considerations, that is most likely to provide data needed by the soils engineer.

E. Special recommendations:

1. Areas to be left as natural ground.
2. Removal or buttressing of existing slide masses.
3. Flood protection.
4. Protection from wave erosion along shorelines.
5. Problems of groundwater circulation.
6. Position of structures with respect to active faults.

V. Seismic considerations

The following published guidelines should be considered when preparing seismic information.

1. CDMG Note No. 37, "Guidelines to Geologic/ Seismic Reports".
2. CDMG Note No. 43, "Recommended Guidelines for Determining the Maximum Credible and the Maximum Probable Earthquakes".

VI. Documentation and implementation

A. The report should consider as the minimum requirement, Chapter 70, Uniform Building Code (1973). Refer to Californis Administration Code, Title 25, Section 1090, Excavation and Grading.

B. All materisl in the report should be relevant to the purpose of the report.

C. All statements should be documented by references or by accurate field observations.

D. Areal photos (originals or suitable copies) should be included to document any discussion on land-slides and faults.

E. The method(s) of field analysis should be discussed in a lucid manner.

Army Engineers study earthquakes in China

The People's Republic of China has had many hundreds of severe earthquakes that span 3500 years of record. Some are the most destructive known anywhere in the world. To tap this wealth of information, Dr. Ellis L. Krinitzsky and Mr. Frank K. Chang of the Geotechnical Laboratory at the Waterways Experiment Station in Vicksburg, Miss., spent five weeks of September-October 1980 in China visiting the sites of earthquakes and centers of research.

The visit was a cooperative arrangement between the Seismological Bureau of the People's Republic of China and the U.S. Army Corps of Engineers.

Field examinations were made of four major earth-quake sites (Fig. 1): Haich'eng, which was predicted seven hours before the event; T'angshan, which may have caused as many as 700,000 deaths; Xian, which killed an estimated 830,000 people in 1556 and was the world's most destructive; and Hsinfengkiang, thought to have been triggered by the filling of a reservoir.

Krinitzsky found many analogies between site conditions in China and the United States. The Xian earthquake area is comparable to that part of the Mississippi Valley that produced the New Madrid earthquakes of 1811-1812, which were felt all over central and eastern North America. However, Xian has an historic record of 3000 years, whereas the historic record at New Madrid is only 170 years. The more complete records in China permit a better under-standing of the earthquake generating process and how they may be operative in America.

The Haich'eng event (Fig. 2) was predicted successfully on the basis of abrupt flow changes in a hot spring and a sudden increase of radon in groundwater.

The fault which produced the Haich'eng earthquake has no very pronounced field appearance. The Chinese success in anticipating this esrthquake was dependent on associated evidences rather than detailed knowledge of the fault itself.

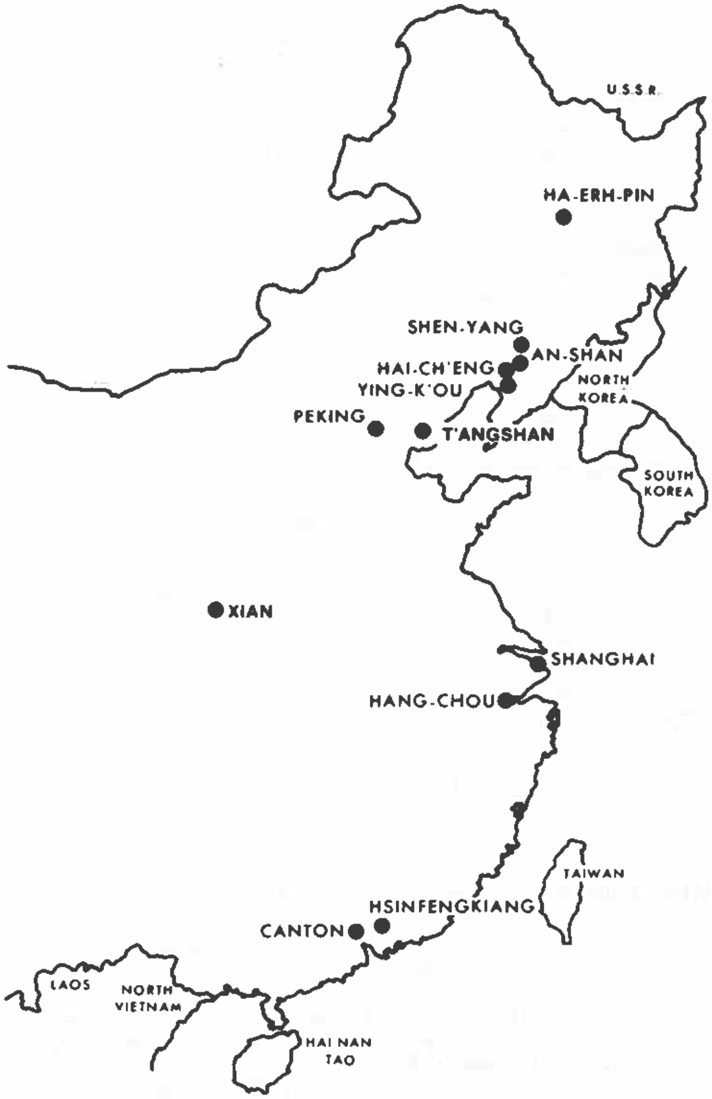

Figure 1. Map showing the locations of the various research centers and earthquake areas visited by the WES team.

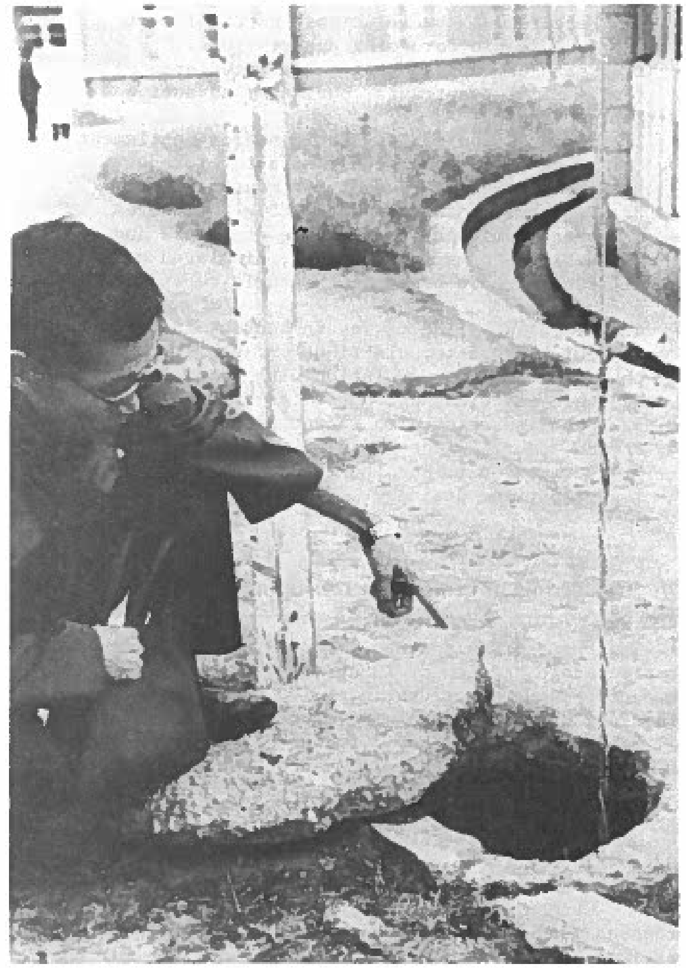

Figure 2. Monitoring water levels and radon counts in a hot spring at Haich'eng, which allowed the correct prediction of a major earthquake.

The T'angshan area is intriguing in that the historic record for three thousand years shows no major earthquakes. There are field evidences, such as marine terraces, that relate to considerable crustal instability, but the historic record was used to show that this was a relatively aseismic area.

The T'angshan earthquake was preceded by monitored effects on the Bowbowshan fault 180 km to the northwest. Groundwater levels changed significantly over a two-year period and the Bowbowshan fault showed buildups and relaxations of strain.

T'angshan caused a liquefaction slippage in Bihe Dam at Minyan Reservoir which holds the water supply for Peking. The site is 150 km distant from T'angshan. The motion was very gentle, only 0.05g at the toe of the dam, barely enough to be felt, yet damaging to a major structure.

The earthquake at Hsinfengkiang is of particular interest to the Corps of Engineers because of its association with the filling of a reservoir. Krinitzsky and Chang found that the recent data collected at Hxinfengkiang casts doubts on at least some of the interpretations of reservoir-caused effects.

At Hsinfengkiang, the major earthquake occurred away from the reservoir in a fault zone which is a contact between a granite mass and a sedimentary section. This contact is itself a focussing zone for concentration of the effects of regional tectonism. The microearthquakes according to recent data at the reservoir are restricted to small bunches that would accord well with a concept of concentration of stresses at inhomogeneities in the granite. The focal depths of the greatest numbers of earthquakes are 7 to 10 km. Krinitzsky observed that were the reservoir the real determinant for this seismicity, he would expect events that were more widespread and closer to the surface.

THE ENGINEERING GEOLOGIST is published four times a year at the Geological Society of America headquarters in Boulder, Colorado.

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