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GROWING IMPORTANCE OF URBAN GEOLOGY

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Urban geology is much too broad a subject to cover comprehensively or in any satisfactory detail in a short presentation. It has been with us for many years, yet possesses a timeliness and an urgency that is regrettably little appreciated. The purpose of this brief paper, therefore, is to alert the geological profession, and others, to the present and future significance of what has been until recently a relatively minor field of applied geology. I hope to increase not only your awareness, but your concern, for concern is surely warranted.

URBAN GROWTH AND ITS IMPLICATIONS

Urban geology is growing in importance in the United States primarily because urban areas are growing. Urban areas are growing because the population of the nation is increasing and also because proportionally more people are congregating in urban areas. The critical factors are the phenomenal rate, magnitude, and changing pattern of urban population growth that have developed in recent decades. The trends are well documented in the census records.

For more than a hundred years, the urban population has grown more rapidly than the rural, until today approximately 70 percent of our inhabitants live in urban areas. From 1950 to 1960, the total population of the United States grew from nearly 151 million to over 179 million, an increase of well over 28 million, or 19 percent. In the same period, the urban population grew from nearly 96½ million to over 125 million, an increase of nearly 29 million, or 30 percent. All the nation's massive population increase during this 10-year interval occurred in urban areas.

Adapted from a talk presented at the 75th Annual Meeting of the Geological Society of America, New York, N. Y., November 18, 1963.

A notable feature of current urban growth is that it is predominantly metropolitan, and furthermore is concentrated in the very largest metropolitan areas. Of the total population increase for the United States from 1950 to 1960, over 84 percent occurred in the 212 Standard Metropolitan Statistical Areas, each of which contains at least one city of 50,000 inhabitants or more. But within these metropolitan areas the growth rate was very uneven. The population of the central cities increased by about 9 percent, while that of the suburban fringes grew by a spectacular 48 percent. Expressed another way, and perhaps more meaningfully, roughly two-thirds of the entire population growth of the United States since 1950 has been taking place in the suburbs. There is no reason to expect any slowing down in the foreseeable future; indeed, acceleration is much more likely.

If the data on population growth and trends seem surprising, the implications are almost overwhelming. The rapidity and the changing pattern of urban growth have given rise to unprecedented problems of city and regional planning in the course of suburban development and urban renewal and redevelopment. The planning problems are noteworthy for their magnitude, diversity, and complexity, but it will suffice here to mention only a few of the areas of greatest difficulty, by way of illustration. Transportation and traffic probably constitute the foremost problem in most growing cities. Also high on the list is the expansion of the various basic city services and utilities, especially water supply, sewerage and sewage disposal, and drainage, including flood control. An immediate concern in the suburbs is the acquisition of appropriate sites for schools and other essential public facilities and for recreational purposes well in advance of local population growth.

Clearly most problems of physical planning are, or soon become, problems of engineering. Therefore the physical planning process necessarily is based to a large degree on engineering principles and practices. Many city planners are, in fact, civil engineers. Since 1923, early in the history of modern city planning, the American Society of Civil Engineers has sponsored a technical division on city planning. Planners, because of their overlap of interests, are coming to realize what civil engineers have been learning slowly and for a much longer time—the value of geologic information.

A major phase of master planning is the evaluation of the advantages and disadvantages of one use of land as compared to another use, so as to make planning and zoning possible for the conservation and maximum beneficial use of land, our most fundamental natural resource. Sooner or later we all pay, directly or indirectly, for unintelligent use of land. So we all have a stake in land-use planning. To a significant degree it is the characteristics of the earth materials underlying its surface that determine how land can be most effectively and safely used. Correlation of the requirements for potential use with pertinent geologic considerations will help assure that land use will not conflict with the limitations imposed by natural conditions. This is especially true when the easily developed sites are depleted and suburban expansion is forced into marginal or hilly areas, where new and more imposing difficulties are encountered. Factors other than geology commonly dictate a given use for land, but this may then make knowledge and consideration of the geology even more important.

Problems of urban land use that are related to geology ultimately involve every aspect of civil engineering through their effect upon the design, construction, and maintenance of specific engineering works. Certain of these problems, such as earthquakes and some landslides, occur as natural geologic hazards inherent in the environment. Other problems, such as instability of cuts and ground-water pollution, pose actual or potential threats because of unwise or poorly planned activities of man. Still others may have more to do with the economics of land use or development than with its safety; problems of difficult excavation or lack of nearby sources of earth material suitable for fill are examples.

The importance of geology to planning and to civil engineering obviously is very great, and is by no means limited to urban areas. On the other hand, it is essential to point out that not all applied urban geology is engineering geology. Sand and gravel and other raw materials of construction are a concern of engineering geologists, but the economic geology of any mineral resource occurring within an urban area may have a critical bearing on local land-use planning and development. Accessibility to valuable mineral lands or their preservation for future use often can be assured through judicious zoning and other regulations.

THE LOS ANGELES AREA—AN OUTSTANDING EXAMPLE

MAN VERSUS NATURE

The Los Angeles area provides an outstanding and instructive example of the growing importance of urban geology. As on the national scene, the importance is the result of the activities of man impinging on the natural environment, but in this megalopolis of southern California both elements are notoriously unpredictable.

Population growth in the Los Angeles area has been truly explosive, and the explosion largely uncontained, as any traveler arriving there by air can easily judge for himself. From 1950 to 1960, the population of the City of Los Angeles grew from nearly 2 million to almost 2½ million, an increase of about 25 percent. Despite the city's vast geographic extent, which is well publicized, the spread of residential subdivisions has been so rapid that now only hilly and mountainous terrain remains as the last large area of relatively undeveloped land. Some 60 percent of the city, or roughly 250 square miles, consists of this hillside area, as it is called in the municipal code. It is perhaps 10 percent built upon, with over 60,000 homes, at least 40,000 of them constructed in the last 10 years. City officials contend there is room in the hills for 2 million people, which also happens to be the population increase anticipated for the city within the next 25 years or so. The story of growth is similar for the entire County of Los Angeles, where about 40 percent of the people of California live. The County's 1960 population of over 6 million was exceeded by that of only 8 States.

The natural setting of the Los Angeles area is characterized by rugged topography, complex and highly variable geology, and a semi-arid climate in which the rainfall is concentrated in a few winter months. This is a combination that resulted in increasingly serious and widespread engineering problems as urban growth accelerated after World War II and thousands of new cuts scarred the hills. Problems of landslides, other slope instabilities, floods, and debris flows have tended to dominate, but the total list is long and the consequences of neglect are extremely costly.

The crisis came with the heavy rains of early 1952, and this crisis turned into a major disaster largely because land developers had generally disregarded things geological. Within months the City of Los Angeles had enacted the nation's first comprehensive grading ordinance and taken other steps to remedy the situation and prevent its recurrence. The County of Los Angeles and other cities and counties within the metropolitan area have since followed suit. Grading and subdivision regulations specify the requirements for rigorous engineering geology and soil engineering investigations, and the regulations are diligently enforced. The relatively minor damage from storms in recent years is proof of how well the controls are paying off.

URBAN ENGINEERING GEOLOGY

The history of urban engineering geology in southern California has been brief but eventful. It had its real beginnings after the St. Francis dam failure of 1928, which led to a State law making compulsory the geologic investigation of all dam sites. Engineering geology played an important role in the planning and construction of the Metropolitan Water District's famed Colorado River Aqueduct during the 1930's. The local profession grew steadily but very slowly until the late 1940's, when the population increase, and hence new construction, began to assume massive proportions.

Employment of engineering geologists in all types of urban investigations in the Los Angeles area was rather impressive by 1953, even before the full effect of hillside development controls was felt, but there has been a 3-fold increase in the last 10 years, from about 50 to about 150 geologists, including some part-timers. A brief summary of present employment in the Los Angeles area is pertinent because it is the most convincing way of showing the extent to which engineering geology is now being used. Keep in mind that the following figures are all for this one urban area. The summary does not include the many men trained as geologists who are now working essentially as engineers, even though their geologic background commonly was a valuable prerequisite for employment. Nor does it include the numerous engineering geologists headquartered in Los Angeles who are not engaged in local urban investigations to any appreciable degree.

Government geologists total about 70. This is more than double the number 10 years ago, chiefly because of increases in State and county organizations. At the Federal level, the largest group consists of some 11 geologists of the Corps of Engineers district office working mainly on major flood control projects, harbor development, and other civilian applications. The Geological Survey is represented by 5 members of the Engineering Geology Branch, carrying out 3 projects of detailed areal mapping, much of which is being done at the request of and in cooperation with the County of Los Angeles.

The largest of three State agency staffs is that of the Department of Water Resources, with 17 engineering geologists engaged in local studies of ground-water basin geology and development, waste disposal, salt-water encroachment and contamination, and related matters. Nine engineering geologists of the Division of Highways are responsible for all local investigations of bridge foundations for the extensive freeway and State highway systems, as well as for many route surveys and materials investigations. Two geologists of the Division of Mines and Geology, which is the State's geological survey, have been doing detailed areal mapping under a cooperative agreement with the County.

The County of Los Angeles, which has a civil service payroll of more than 40,000 persons, employs engineering geologists in two of its biggest departments. Ten geologists work for the Flood Control District on a wide variety of projects about equally divided between the District's two integrated programs of flood control and water conservation. Their principal effort currently is with salt-water encroachment barrier projects. The Engineering Geology Section of the County Engineer's Department came into existence only 4 years ago, and now has a staff of 5 professionals who are nearly swamped with responsibilities in all geologic aspects of hillside development control and major capital projects. These geologists, in addition, serve as advisers for most other County departments, including the Road Department and the Regional Planning Commission.

Within the City of Los Angeles, several geologists are employed by the Public Works Department, mostly on hillside investigations, and three geologists work for the Dams and Foundations Section of the Water and Power Department, which is the largest municipally owned utility in the United States. Recently a geologist position was established within the Department of Building and Safety in order to provide needed assistance in control over grading on private property.

The Metropolitan Water District of Southern California, a public corporation, employs only 1 or 2 geologists at present, though it has had a larger staff in the past during periods of major construction programs.

The field of private utilities is of minor importance locally, with 3 engineering geologists working for the Southern California Edison Company.

The greatest number of geologists is in the field of private geological and engineering firms and consultants, for this field has had a tremendous growth, chiefly because of the necessity or requirement for detailed geologic mapping in connection with hillside residential developments. In 1953, perhaps 4 full-time engineering geologists were in private employ. Today there are about 28 in engineering geology firms plus another 20 or so working for soil and foundation engineering companies. Noteworthy is an engineering geology firm that started in 1959 with 2 partners, now has 12 geologists, and recently added a soil engineering group in a reversal of the usual procedure. Part-time engineering geology consultants have increased slightly in number in the past decade, to about 20, but they now handle much more work. More than one college faculty member has enough business to keep full-time assistants occupied.

LESSONS TO BE LEARNED

The importance of the Los Angeles experience to geologists, engineers, planners, and indeed to the public, is that it illustrates the sort of thing that can happen and already is beginning to happen elsewhere, though on a lesser scale and with variations because of differing local conditions. Other urban communities would do well to take note and hopefully avoid some of the more violent growing pains in the acquisition and application of geologic information. In particular, the experience suggests an ideal sequence of mapping investigations to best meet the needs for geologic data in an expanding urban area.

First, and an absolute essential, is modern general-purpose mapping of quadrangles or other large areas, such as is undertaken by Federal and State surveys. Where possible, this should precede urban development so that the maps can serve as guides for land planning and zoning, and provide background for more-detailed local studies. The mapping of suburban fringe areas before the central city generally will meet greater needs first and take advantage of better exposures. The 7½-minute, 1:24,000-scale (i.e., 1 inch equals 2,000 feet) topographic maps are becoming the standard base for urban planning activities throughout the country, and thus are also the most appropriate base for general geologic mapping of urban areas. However, in some urban areas geologic complexities may make desirable initial large-scale mapping on an enlarged base.

The most useful general-purpose maps for urban development are those that emphasize geologic processes and characteristics of geologic materials that are significant to land use and civil engineering. But even where such emphasis is lacking, valuable guidance can be derived from interpretations of the basic geologic data.

The second stage in the mapping sequence consists of larger scale and commonly special-purpose mapping of selected areas. Both the County and the City of Los Angeles have recognized the need for maps at a scale of about 1 inch equals 400 feet in areas where landslides are prevalent and where no geologic maps were available at scales larger than 1:24,000. As part of the cooperative program between the County and the State Division of Mines and Geology, the broad coastal peninsula of Palos Verdes Hills recently was mapped at a scale of 1 inch equals 200 feet, with subsequent compilation at 1 inch equals 400 feet. This is an area of approximately 26 square miles. The assembled field maps, properly fitted together, would measure about 8 by 12 feet! Geologists of the City of Los Angeles have embarked on an ambitious program of mapping some 80 square miles of hilly and mountainous terrain on new photogrammetric base maps at a scale of 1 inch equals 400 feet. Such activities are by no means limited to governmental surveys. Private engineering geology firms have done extensive mapping at comparable scales for private developments covering up to tens of thousands of acres.

The third stage in the mapping sequence, and the one involving by far the greatest number of geologists, consists of extremely detailed investigations, chiefly for individual hillside subdivisions or specific engineering projects. A common scale for tentative tract maps is 1 inch equals 100 feet, and for final grading plans 1 inch equals 40 feet. Most such mapping is for private development and is done by geologists in engineering and consulting firms.

MEETING THE NATIONAL NEED FOR URBAN GEOLOGIC INFORMATION

The population figures for the United States show that urban growth, with its Pandora's box of planning and engineering problems, is not peculiar to Los Angeles. It is a nationwide phenomenon. And so also the need for urban geologic information, both basic and specialized, is nationwide. Much can and should be done to take full advantage of such geologic data as are already available in published and unpublished form, but for most urban areas these will afford at best no more than an interim and partial solution.

New York was the first and still is about the only large city in the nation with anywhere near adequate engineering geology information. Most metropolitan areas of the United States desperately need new, detailed mapping, and this can only be achieved through a greatly magnified engineering geology effort involving municipal, county, and State agencies and private firms, as well as our universities and colleges. The master key to real progress belongs to the local governments. They can provide the greatest stimulus for urban geologic investigations, and they are in the best position to insure that the results are applied for the maximum benefit of their citizens. Cities and counties can use the geologic information not only in the formulation of long-range policies and plans, but in the day to day applications that are possible with continuity of local operation.

The recent history of the geological profession in Los Angeles and in a number of other cities fosters optimism about the future job outlook for well-trained engineering geologists interested in urban work. The major emphasis must always be on quality rather than quantity, however, because this is work that deserves and demands the best talents. Many of our academic institutions would do well to reexamine their curricula with a view to improving the capabilities of their graduates for this field of specialization.

The U. S. Geological Survey has been mapping cities for many years as part of its national mapping responsibility. The 1902 folio of the New York metropolitan area was a notable early effort. Most of the older maps, however, are no longer adequate to meet modern requirements for more detailed, specialized, and up-to-date information. In its limited program of urban geology studies, the Geological Survey hopes to encourage by example the greater use of engineering geology in urban areas, and to educate public agencies and private concerns in the needs and applications of this field to the end that they will develop their own capabilities.

Mapping and related research by the Geological Survey in urban areas is intended to provide general background for more detailed site investigations. Individual projects tend to emphasize different aspects of the geology, depending on the local situation. Studies by the Engineering Geology Branch are currently underway in the following metropolitan areas: Boston, Mass.; Washington, D. C.; Great Falls, Mont.; Rapid City, S. D.; Omaha-Council Bluffs, Nebr.-Iowa; Salt Lake City, Utah; Denver and Pueblo, Colo.; Seattle, Wash.; and San Francisco-Oakland, San Mateo-Palo Alto, and Los Angeles, Calif. Studies have been completed in recent years in Anchorage, Alaska, Knoxville, Tenn.; and Portland, Oreg., and the reports have been published.

The problems of urban growth are a tremendous challenge. Planners and engineers need all the help they can get to meet the challenge most effectively. It is time geologists fully appreciated that a fundamental part of this help must come from their own ranks. The challenge to the geological profession is actually the more urgent because much of the geologist' work should be completed before that of the planners and engineers begins. In short, this is a time of opportunity but also a time for responsibility. We have an obligation as scientists, as educators, and as good citizens to see that the benefits of geologic information are brought to bear as widely and fully as possible in the solution of problems of urban growth.