Applied Quaternary Studies

by B. P. Hageman

The application of Quaternary studies to land use planning and development is in great need of improvement. The significance of Quaternary deposits and processes is rarely understood by politicians and decision makers, and many geologists also appear to be unaware of the societal impact of their findings. The author argues the need to correct these situations and to develop further the techniques and methods of study of Quaternary deposits. (Ed.)

Significance of Quaternary Deposits

A knowledge of Quaternary geology is essential for planning comprehensive land use and for the development of infrastructure. The potential value of applied Quaternary geology to society has, however, not been fully realized, and several primary factors must still be addressed. First the significance of Quaternary deposits for planning, development, and society as a whole should be emphasized (e.g. Lüttig, 1975; Bender, 1986). Second most politicians and decision-makers are ignorant of the need to understand Quaternary deposits for the profitable and responsible use of surficial resources. Many Quaternary geologists are also unaware of the decisive role this field of science should play in the development, enrichment and survival of human society. Finally improvements are needed in the techniques and methods of investigation used in applied Quaternary geology.

The importance of Quaternary processes and sediments should be readily apparent. This is evident even where the Quaternary succession is solely a product of weathering, highly accentuated by the cyclic alternation of glacials and interglacials. Understanding the development of the Quaternary weathering blanket is of crucial importance, not only because of the implications for pedogenesis and agriculture, but also because of the implications for civil engineering and environmental management. These deposits, commonly limited to thin blankets or veneers, are vulnerable to erosion, or may easily slide over impermeable sloping rock faces.

Equally important, if not more so, are sequences of Quaternary sediments accumulated in river valleys, floodplains, estuaries and deltas, eolian sequences of loesses and sands, and vast expanses of peat. Quaternary sedimentary assemblages in river systems and on coastal plains are frequently the sites of prosperous development, for example in South-east Asia.

Easy access to the seas and the hinterland by means of navigable rivers, the flat surface, the availability of groundwater, and the fertile surface layers of these areas all favour efficient, diversified, and beneficial urban and rural development. On the other hand, these assemblages show abrupt horizontal as well as vertical changes, as they are formed by rapidly changing sedimentary processes related to complicated stream and coastal systems (e.g. Hageman, 1963; Mulder, 1979). Sedimentation here is influenced not only by tidal phenomena and changing river runoff but is also related to long-term cycles of global sea-level changes

produced by glaciation (Fig. 1 and Pirazzoli, 1985). In addition there commonly are dramatic differences in physical parameters (such as bearing capacity, compressibility, cohesiveness, permeability, and cation absorption capacity) among unconsolidated layers of gravel, sand, silt, clay, and peat (e.g. Nutalaya and Rau, 1981).

The picture that emerges when all factors are considered is commonly one of a complicated (and unexpected) three-dimensional anatomy, despite the fact that the generally flat surface of a coastal plain can produce a misleading impression of a simple, uniform and reliable subsoil (Hageman, 1984). In these areas more than anywhere else, site selection and environmental planning are crucial for areal management. Such a program requires that construction should be based as much as possible on favourable natural patterns, taking into account factors such as bearing capacity, topsoil fertility, and vulnerability of the geo-environment. Attention must also be paid to responsible management of the available groundwater resources and building materials (sand gravel, and clay): accessibility to these should be maintained (Oele, 1973; Bühl, 1982, 1983; Lüttig, 1979).

To be successful in this, however, Quaternary scientists have to be sure of their messages and their arguments, which in many respects differ greatly from those used when dealing with a purely scientific audience. This field is far too important for mankind to be of interest only to ourselves in isolation, to bloom only as an exotic and largely unseen flower in the wilderness.

The Unsatisfactory Development of Applied Quaternary Science

Although Quaternary geologists have not developed the applied side of their discipline, under the wings of civil engineering, hydrology and agriculture, some aspects of Quaternary geology and their practical applications have been extensively explored and developed, such as in soil

mechanics, geohydrology, and pedology. For example, the determination of physical properties, the use of statistical calculations, and the development of special investigation methods in the field and laboratory are of great value, and should be used in close conjunction with studies of Quaternary geology.

These specialities developed mainly as service disciplines, unconcerned with geological processes and stratigraphy. Moreover, these "Cinderella" disciplines are mostly site-specific. Reliance is placed primarily on the physical properties at a given allocation, and the sediment distribution pattern is derived from mathematical interpolations and extrapolations, based solely on data from the site itself. Not enough attention is paid to facies transitions and abrupt, erosional boundaries that cannot be predicted from mathematical models, but which are often clear to the trained geologist. Predictions based on a knowledge of sedimentary or erosional processes and knowledge of the resulting geological patterns also generally do not belong to the arsenal of tools of the civil engineer, agronomist or hydrologist. As a result, these disciplines are unable to produce alternatives for intelligent decision-making environmental planning.

An equilibrated management plan for protecting the geological environment should emphasize the need to understand sedimentary profiles, in order to assess the risks regarding waste disposal, over-fertilization, and industrial pollution. Even after these geological data are considered there may be conflicts of interest between different groups involved. Knowledge of the alternatives, however, will improve the quality of decision-making to a great extent, enabling consequences to be predicted and countermeasures planned.

Educating the Decision-Makers

The vast majority of politicians and decision-makers are drawn from business, economics, and law. Almost by definition, these people have never received any formal education in aspects of the natural sciences that are of decisive importance to human life. On the contrary, their world with its ever elastic legal and policy processes differs completely from the one dominated by the hard facts of nature, dealing with places, processes, qualities and quantities. This traditional background prevents politicians and decision-makers from understanding the importance of natural resources and from incorporating the often harsh realities of nature into their systems.

A better earth science education in secondary schools seems to be the only way to provide future politicians and decision-makers with an adequate background in this subject. Such an education must not only focus on the highly romantic science of the evolution of the Earth, but also on the role of the crust as the only source of water, fertile land, building materials, and stable sites for development, as well as the traditional energy and mineral resources. Most important of all, earth-science education must inspire future generations with the absolute conviction that responsible and beneficial management, based on an adequate inventory of earth resources, must be the starting point for all environmental planning and for ensuring human survival (cf. Lüttig, 1978).

Educating the Quaternary Scientist

It is, however, unfair to blame only non-geologists for the lack of use of Quaternary geological information in decision-making. Quaternary scientists themselves have only recently recognized the importance of their input in solving many of the problems faced by society. The sensitivity of Quaternary deposits to groundwater pollution, the role of the distribution and continuity of clay layers in protecting aquifers, and the rapid dissemination of the products of over-fertilization in permeable deposits have, inter alia, "sounded the alarm" in the camp of Quaternary geologists.

Figure 1: An emerged Holocene reef (foreground), Bora-Bora, French Polynesia. Photo courtesy D.R. Grant.

There is, moreover, a rapidly growing interest in palaeoclimatic reconstructions using Quaternary geological data, and cooperation with other scientists studying global change has intensified.

On many other fronts, however, Quaternary scientists are still reluctant to emphasize their knowledge. The crucial role that should be played by a stratigraphically and sedimentologically well-understood surface or near-surface sequence in regional planning and management is still obscure to many Quaternary geologists. They should recognize as "first order instruments" the practical value of knowing the distribution of sedimentary layers with a relatively high bearing capacity interbedded with peats and clays; the importance of an inventory of building materials such as sand, gravel, and brick-clays (which comprise the greatest mass of material mined on our globe) and the need for a well-documented insight into the sensitivity and stability of sediments in zones of coastal and fluvial erosion in conjunction with pollution problems. Quaternarists should thus be constantly "knocking on the doors" of decision-makers.

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