UNHEEDED GEOLOGICAL WARNINGS FROM THE 1976 GUATEMALA EARTHQUAKE

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INTRODUCTION:

I was requested to give a geological paper understandable and of interest to an international earthquake symposium audience consisting of engineers, economists, reconstruction workers, government officials, financial officers, as well as earth scientists. Geologists spend so much of their time looking into the past that we tend to overlook their ability thus gained to look into the future. Our main problem in practical terms is to translate our predictions, couched in a geological time scale of thousands and millions of years, into an economically realistic span of tens and hundreds of years.

Earthquake reconstruction and ordinary construction go on in the face of geological misgivings because we cannot establish a clear and present danger, cannot predict an immediate disaster that would force us into making current sacrifices for future benefit.

The author realizes that life must go on, that neither government nor private initiative can remain paralyzed while geologists go through their well known vacillations of perhaps, possibly, maybe, and sometime. But, granted the means, earth scientists can give concrete answers which are economically viable. This, I believe is the key; if we do not have ready answers for earthquake problems, there must be investigation and research directed at solving these specific questions. Ignoring problems because there are no immediate answers, or because they require financial sacrifice for a delayed future benefit is a moral and professional blight.

Obviously, there are no ready, all-inclusive solutions to a complex geological, engineering and socio-economic phenomenon such as an earthquake. Investigation is the key to future practical solutions; ignoring problems is not.

THE PROBLEMS

I wish to mention several socially significant earthquake-related problems which are of critical engineering importance, but are not under major direct investigation with specific solutions in mind, at least as far is publicly known to the local geological community. It should be pointed out here that land in the Guatemala valley, is extremely valuable, not only because of expanding population pressure, but because of its traditional use for investment and speculation.

The local geologists are few in number and mostly assigned to high priority projects that had to be continued after the earthquakes. None had earthquake experience or skills directly applicable to the problems. Few would be available for special training. Therefore, it is most likely that the studies called for here would mostly have to be made by foreign experts. It would appear that because of the inadvisability of embroiling foreign governmental missions in local controversy, it may be wisest to have the actual investigations done by non-governmental entities. The general background work, such as ages and amount of last fault movement and stability of slopes

can be done by governmental missions, but the actual specific applications on individual foundation studies perhaps should be done by private consultants.

After the main earthquake, and during the period of frequent aftershocks, the local geologists were beset by questions about the safety of building near faults and ground cracks, and literally overwhelmed with requests to visit landslide sites in order to find the supposedly causative fault. The latter requests were buttressed, we are sure, by the great publicity given to plate tectonics and faults, making it convenient for engineers, architects and builders to overlook the fact that steep slopes may slide, along with houses built upon them, when there is earthquake shaking. There is no need for, and seldom was it found, that faults were the direct cause of landslides.

Now there are almost no inquiries at all relating to earthquake dangers. Have the geological hazards miraculously disappeared or been remedied? Are they being treated in the traditional manner, according to the experience and conscience of individuals? Or are they being ignored?

Certainly the largest projects, because of the requirements of international financing, are reviewed for earthquake hazards. However, we believe that the current general silence on earthquake problems is related to the fading memory of the 1976 disaster and the general belief that another one will not occur in the immediate future, at least not during the economic life of the project, or in the worst of cases, not while the designer or builder can still be held accountable.

FAULTING

Two general types of faulting occurred during the 1976 earthquake. The causative Motagua fault zone created a relatively narrow zone of en echelon ground break which could be fairly easily traced and defined. Although the rupture crashed through several towns, for the most part it went through undeveloped rural lands. As a simple rule of thumb it was recognized that it would be unwise to rebuild over the actual rupture. How far away from the fault was reasonably safe has not been determined.

The other type of faulting, of much greater economic impact, was secondary faulting along the western side of the Guatemala City valley, caused by the Mixco fault system. This is a several kilometers wide zone of discontinuous faulting, fracturing, and ground break. The exact nature of all the ground break has not been determined, but much of it is due to faulting. The area affected is either urban land or new subdivisions under development. The troubles are compounded here because it is not a single, well defined line of faulting which can be studied and prudently dealt with

Common sense might warn against building on these cracks, but how far away is safe? How are they to be located? What are the possibilities that a new set of interfingering fractures will open up with the next earthquake? These are just technical

engineering questions. Think of the economic and social overtones in this area of rapid urban development.

Obviously, the ideal solution would involve a multidisciplinary approach involving geologists, engineers, bankers, insurers, and public officials. It might even be called civic planning-nonexistent at present. Instead we are essentially avoiding the problem with makeshift solutions or simply covering over the ground. Perhaps these are the most practical alternatives, but surely we can at least make society aware of its options. Until the problem is attacked on a technical basis, the current solutions tend to be self-serving.

The geological aspect of the problem is tied to when and how much faults have moved in the past, so as to get an idea as to how they may behave in the future. Their past behavior is a measure of the future. Historical records are best, but very little is available for Guatemala. We have few specific details about the 1917 earthquake that destroyed Guatemala City. Therefore, we must look into the geologic record for information; for prehistoric data, it is the only source.

Much of the Guatemalan highlands have been covered by pumice and ash as the youngest geological units. By dating these units and identifying where and how much they have been displaced by faulting, it is possible to get an idea of the degree and age of past faulting.

In part because geological research is only beginning in Guatemala, we do not have much age information on our geological units. Current volcanologic research points towards a 90,000 years old age for a massive pumice unit that fills much of the highlands. (W. Rose, personal communication). The thinner pumice and ash units that mantle this dated pumice would, of course, be younger. The fact that these pumice units are displaced by faults proves that there has been active faulting in the Guatemala valley within the last 90,000 years, some of which was reactivated in 1976. Further research would surely establish the age of some of the younger pumice units, thus better defining the age of recent fault movements.

Faults moving within the last 100,000 years are generally considered as potentially active faults, and everywhere in the world are treated with the utmost caution. Certainly, all large construction sites and civil projects located on or near known faults call for the most careful scrutiny.

We recognize that the geologists have properly identified only a few of the less than 100,000 years old faults. If the known faults, with few and honorable exceptions, are utterly disregarded, how much of a concerted effort to discover and evaluate unknown faults can be expected?

LANDSLIDES

Immediately after the earthquake geologists were flooded with requests from engineers and architects, as well as concerned laymen, to make field investigations in

order to find the faults that supposedly caused the widespread landslide destruction. As is well known, even at the time of the catastrophe, the landslides were caused by earthquake shaking, not fault rupture, and the great human and material loss was due to construction on, or adjacent to canyon walls, not to some mysterious "geological fault".

Untold thousands still live in precarious situations on and adjacent to canyon walls, exposed to the next earthquake disaster. Mass relocation is obviously beyond the possibility of Guatemala at present. Investigation, however, can be channeled to establish a more technical basis for what might be reasonably termed dangerous areas, suggest practical solutions, and create some order of priorities. The results must be made publicly available, if not publicized. Again, the current trend is to try to forget the last earthquake and depend upon the next occurring some time far in the future.

EASTERN GUATEMALA CITY FAULT SCARP

We know that there is a major fault zone, termed the Santa Catarina Pinula fault, similar to the Mixco fault zone, that forms the eastern side of the Guatemala City valley. This fault zone apparently was not active during the 1976 earthquake. The fault scarp is now being rapidly urbanized, including high-rise buildings, hotels, schools, and already existing water treatment plants. Undoubtedly development on this side of the valley is accelerating because of the absence of noticeable ground break from the 1976 earthquake. Thus, it may be considered safer than the western side of the valley.

Geologists have every reason to expect this fault zone to behave similarly to the Mixco fault zone. We don't know why it didn't move in 1976 and we don't know what the possibilities are of it being active in the future. But the combination of a known fault zone, steep slopes, heavy seasonal rainfall, and a seismically active area presents potential hazards, and surely calls for careful investigation. We know of none underway.

CONCLUSIONS

There are no public answers to geologically-related earthquake problems that are of immediate concern to the general population, such as construction in relation to faults and ground break, landslides, and the urbanization of the eastern Guatemala City fault scarp. There does not appear to be much research or investigation directed specifically at providing practical solutions to these problems. There are enormous social, economic, and political complexities that must be interwoven with geological and engineering investigations and conclusions.

Geology and history tell us that Guatemala will suffer future destructive earthquakes. The current trend is to ignore the warnings and to hope for the best in the

future. Perhaps lending and insurance institutions, in the harsh realism of self-interest, will help counteract our present self-serving course, by forcing us to face geological reality. This could be done by initiating the financial incentives,with their corol-lary penalties, that would stimulate research and studies in Guatemala directed at practical solutions for the population's benefit. More wistfully, I hope that this Guatemala earthquake symposium will encourage us to focus more of our effort on the direct needs of the people we serve, and who in the last analysis, support us.

BIBLIOGRAPHY

As a gentle reminder to the concerned professions and public, the following publications are listed. The four maps, showing fault systems in Guatemala, have been published in Spanish and English, and are publicly available at the Instituto Geográfico Nacional, Guatemala City. The earthquake report can be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Geologic map of the Republic of Guatemala, 1970; 1:500,000.

Geologic map of the San José Pinula Quadrangle, 1975; 1:50,000. (Includes eastern side of Guatemala City valley)

Fracture map, earthquakes of February 1976, Guatemala valley, 1976; 1:25,000.

Geologic map of the Guatemala City Quadrangle, 1977; 1:50,000.

The Guatemalan earthquake of February 4, 1976, a preliminary report: U.S. Geological Survey Professional Paper 1002, 1976.