SOIL - STRUCTURE INTERACTION IN THE MAY 31, 1970 PERUVIAN EARTHQUAKE

by

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SYNOPSIS

The Peru earthquake of May 31, 1970 was probably one of the most destructive natural disasters recorded in the Western Hemisphere. It affected the west-central area of Peru and it has been estimated by one oficial source (Ericksen, Plafker and Fernandez, 1970) as having taken 70,000 lives caused 50,000 injuries and destroyed or rendered uninhabitable some 200,000 buildings. The principal areas devastated by this earthquake were the coastal band south of the city of Trujillo and the valley of the Río Santa as shown by the hatched area of Fig 1. The main city in the Santa Valley, Huaraz, was devastated throughout its older section. An explanation is advanced with regard to the reasons for that occurrence.

PHYSIOGRAPHIC SETTING

One of the most affected areas by the earthquake of May 31, 1970 was the Santa Valley, more commonly referred to as the Callejón de Huaylas (Huaylas Corridor). The Santa River flows between two major mountain ranges of the Andes, the Cordillera Negra on the west and the Cordillera Blanca on the east.

Huaraz, the largest city in the Santa Valley and the capital of the department of Ancash had about 65,000 residents. A majority of deaths in Huaraz were in the older section of the city where practically the totality of adobe buildings collapsed, killing their occupants who fled into the narrow streets for safety. Other areas of the city of Huaraz bore relatively well the strong and prolonged shaking even though the quality of construction was in many respects similar to the area devastated.

The geomorphological characteristics of the city of Huaraz are given in Fig 2. The urban area is located between the two mountain ranges to the east of the Santa River. Most of it has been formed by torrential action, avalanche debris or coluvial debris provenient from the higher areas. In particular, it is noteworthy the avalanche cone marked as AL-Q2, which was produced by the debris fallen onto that area in 1941 and originated in the bursting of the natural containment of a glacial lake situated above Huaraz. It is also interesting the area densely populated of Huarupampa which was formed by the temporary damning of the Santa River in Recent times and which actually constitutes a lake bed conformed mainly by succesive layers of sand, silt and clay. Most destruction occurred in this area.

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SOIL - STRUCTURE INTERACTION

The results of a soils investigation conducted in 1972 for the Peruvian Government are shown om Figs 3 and 4.

Fig. 3 shows the zonification of the city made on the basis of soil characteristics and Fig. 4 presents the areas where the water table was found at a shallower depth than 3 meters. Zone I corresponds very closely with the area more distressed and where most deaths were recorded. Depths explored were in the order of 10 meters. However, it is estimated that the soft sediments encountered extend to depths as large as 100 meters or more.

No actual instrument measurements were made in Huaraz during the earthquake. However, subsequent investigations suggested a maximum intensity of shaking of VII on the Modified Mercally scale. According to several accounts the vibrations began as a gentle swaying which was followed by approximately 45 seconds of hard shaking- In most places, the adobe structures reportedly began to collapse after about 15 seconds of strong vibrations.

It has been shown, (Ohsaki, 1969), that very flexible structures such as wooden buildings have natural periods of vibration of the order of 0.4 sec., very similar to the natural period of vibration of soft alluvial soils and, therefore, flexible buildings on those soils are more vulnerable to earthquake damage due to a phenomenum of resonance. It is therefore only natural to postulate that a similar mechanism acted in the case of the 2 and 3 story Huaraz flexible adobe buildings, with natural periods of vibration of the order of 0.4 - 0.5 sec, resting on the soft sandy and clayey soils. Furthermore, considering the initial cracking produced in the buildings by the resonance action and the duration of the earthquake, it is reasonable to believe that the distressing input remained almost constant during the duration of the shaking, causing cracking and local failure to continue to develop, obviously producing ultimately overall failure of the buildings. Similar edifications built on more rigid soils with shorter natural periods of vibration did not probably go through this sequence of events. On the other hand, the zone of Pedregal wich registered a fairly high ratio of collapsed adobe buildings, despite being located on rigid soils, with its situation at the top of a sloping ground, probably confirms conclusions reached before with respect to wave amplification on the crest of sloping terrain (Idriss and Seed, 1967).

Official peruvian agencies are now taking into account the mechanisms described above, in the planification process of reconstruction of the cities destroyed by the May 31, 1970 earthquake.

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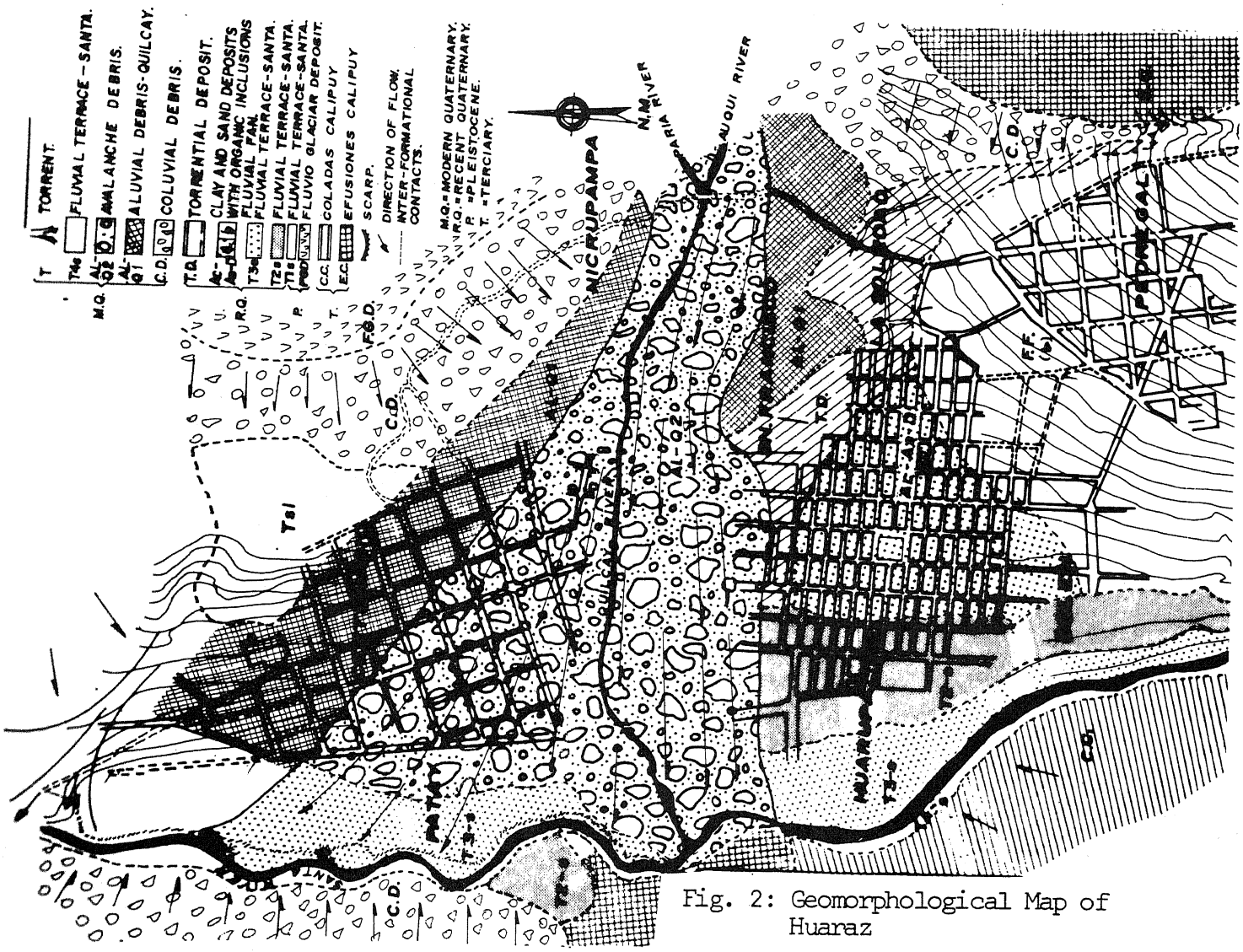

Fig. 2: Geomorphological Map of Huaraz

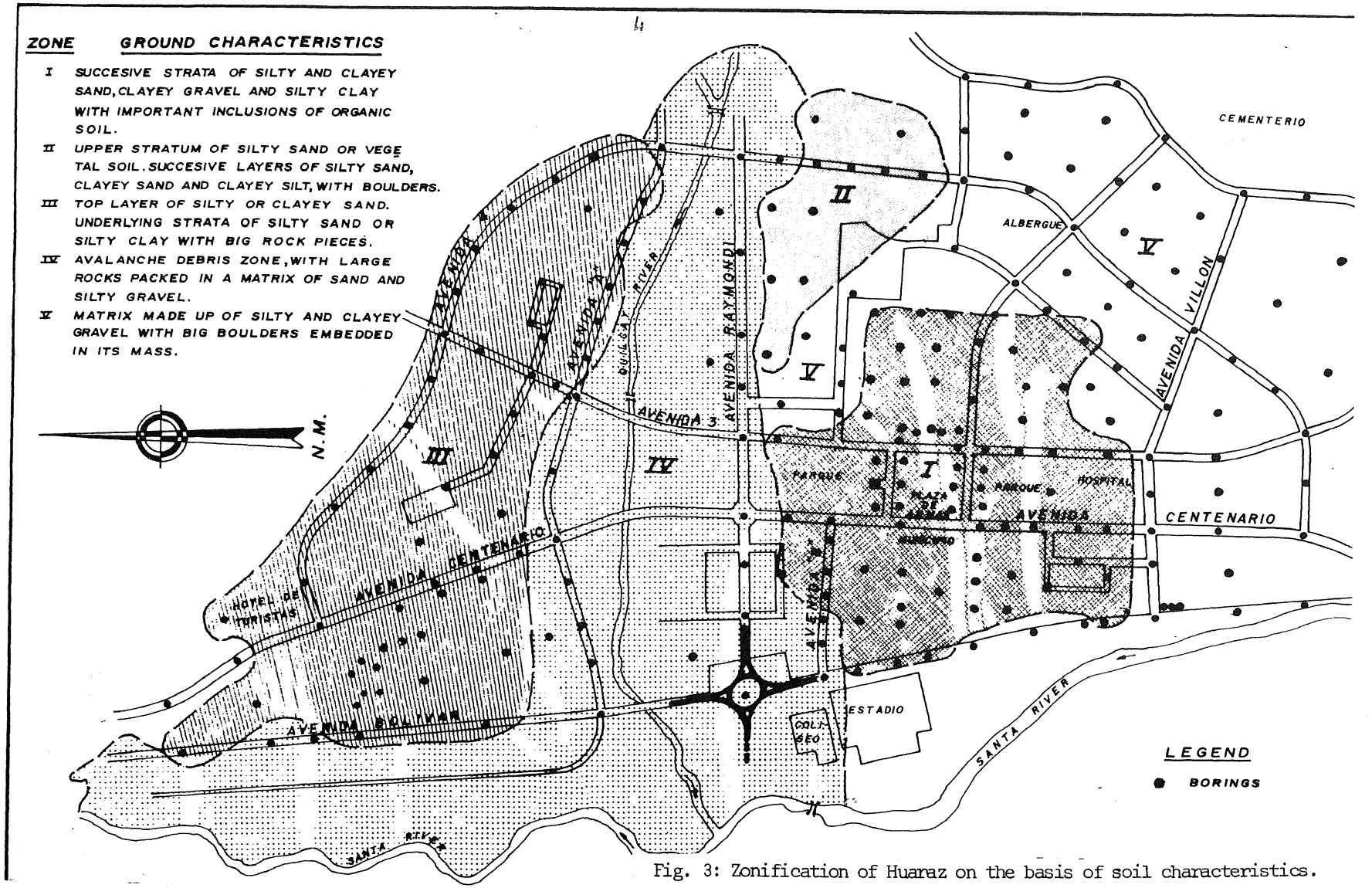

Fig. 3: Zonification of Huaraz on the basis of soil characteristics.

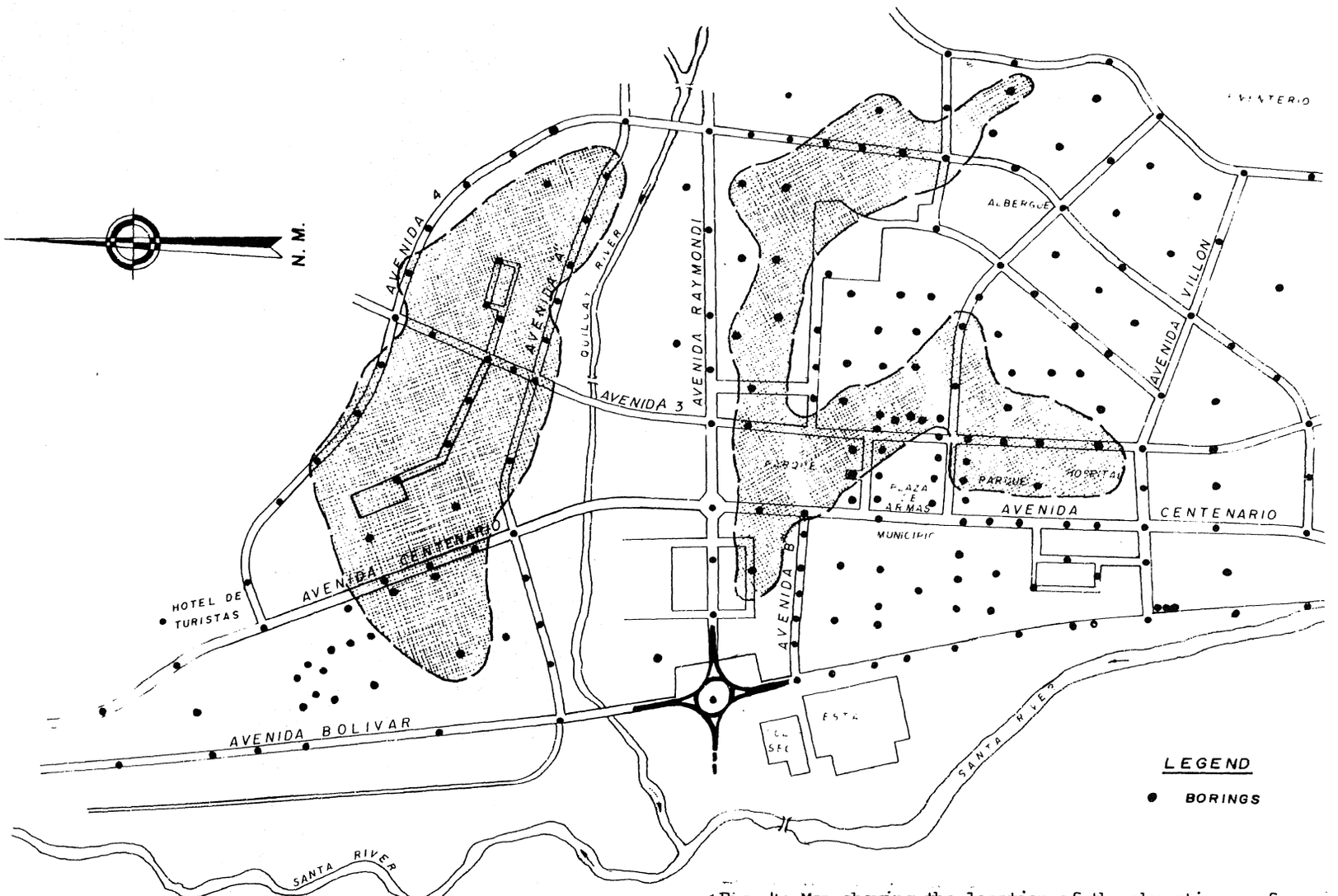

Fig. 4: Map showing the location of the phreatic surface.