PHYSICAL ASPECTS OF THE DISASTER

Geology

The following account is derived from papers by Segré (1919), Manfedini (1951), Ceretti (1974), Ceretti and Colalongo (1975) and Nanni (1980), and, to a lesser extent, from my own field visits.

At the Barducci landslide site the stratigraphic column consists of the following formations, from the base (maximum known depth 170 m) upwards: 1) blue marly clays of the lower or middle Pliocene; 2) blue marly clays of the upper Pliocene, differing little from the previous formation; 3) fossiliferous cobbles, gravels and sands of the lower Quaternary; and 4) mainly clayey alluvial and wash deposits (Ceretti, 1974). The deposits pass from compact, marly Pliocene clays at the base, to weaker, more complex or disturbed sediments above (Nanni, 1980). To complete the picture, stream valleys and the coastal strip are mantled by sandy clays forming a recent colluvial deposit; and cobbles, gravels and medium to fine sands occur along the coastal strip (Selli, 1951).

Three main tectonic phases have created the structure of the Anconetan region. In the middle Pliocene tectonic disturbance produced most of the structure that can be observed today. From the upper Pliocene to lower Pleistocene marine sedimentation was renewed during a phase of tectonically-induced subsidence, and finally, a slow uplift brought some of the Quaternary sediments to heights of 250 m to 300 m above sea level (e.g., at Montagnolo).

Ancona itself is situated on a monocline and there are anticlines in the Anconetan area at Falconara, Varano, Monte Conero and Agugliano. There are also a number of synclines, running WNW-ESE, of which the syncline of

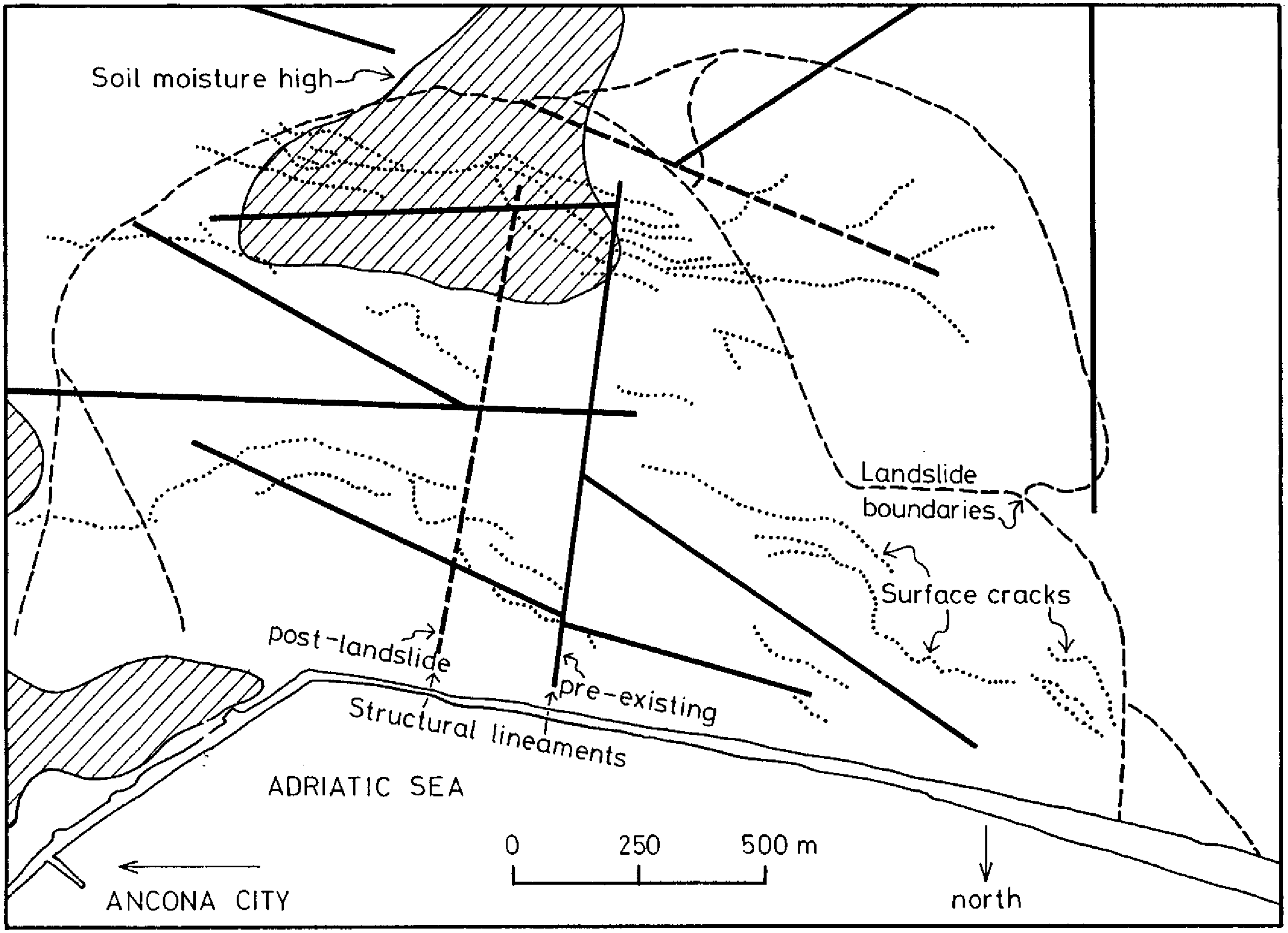
Tavernelle crosses the 1982 disaster area, ending close to the coast near Torrette (Figure 4). This structure is asymmetrical and is superimposed towards the NE upon the Ancona monocline, as a result of inverse faulting that has thrust it some 300 m over the adjacent structure.

The seismicity of this area is, given its complex structure, still poorly understood, but seismological measurements over the period June, 1973-September, 1976 indicated three concentrations of epicenters (Crescenti, et al., 1978). In the sea north of Ancona earthquakes occurred during the measurement period with foci up to 6.1 km deep at Scoglio del Trave; on the coast southeast of Ancona, hypocenters were 2.7-6.7 km deep; and in the vicinity of Falconara Marittima and Torrette, west of Ancona, they were 2.5-4.8 km deep. No epicenters were located in the 1982 disaster area.

The relationship between landsliding and the geology of the disaster area is the focus of several hypotheses. Manfredini (1951) discussed the separating by faulting of emergent pre-Pliocene sediments NE of Camerano and Posatora (including the Ancona city area) from the Pliocene and Pleistocene deposits to the SW. This large-scale division is carried into the 1982 landslide area and, by virtue of tectonic disturbance, has contributed to the destabilization of surface materials there. Manfredini also cited the presence of fault intersections as adding to the lack of stability in the area, a fact that has received additional confirmation with the discovery of new lineaments following the 1982 slide (Figure 4). However, other authors (e.g. Segre, 1919; Selli, 1960) have blamed instability on the complexity of sediments and the lack of consolidation in Pleistocene deposits (coupled with weathering effects reducing the strength of the Pliocene marly clays).

Figure 4

1982 ANCONA LANDSLIDE: SOIL MOISTURE ANOMALIES, LINEAMENTS, SURFACE CRACKS



Courtesy of dott. Leonardo Polonara, Regione delle Marche.

Meteorology

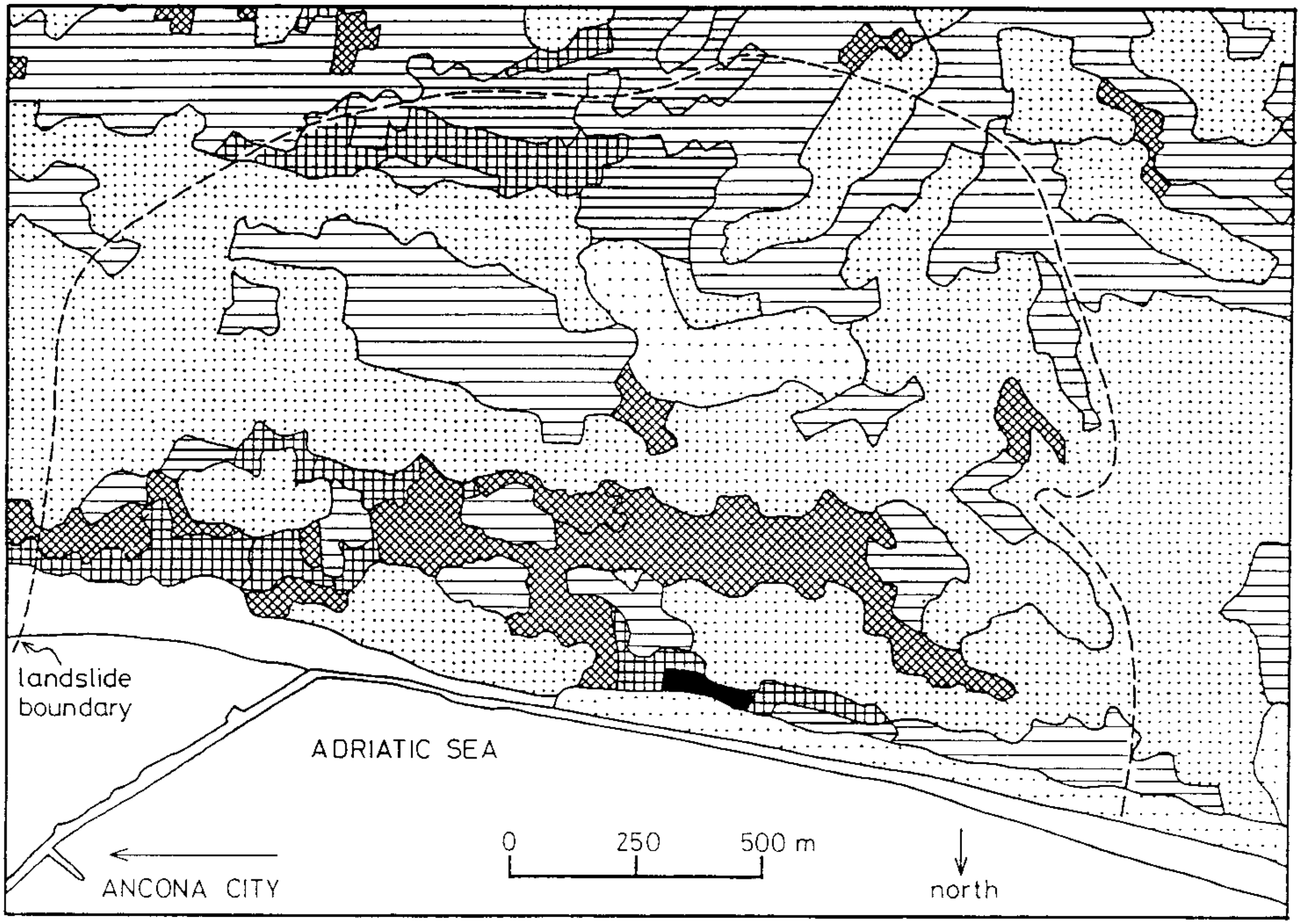
Given that the above geological factors are related to slope failure by pore pressure increases during saturation of the slope, it is necessary to consider the precipitation regime of the disaster area. As the volume of moisture needed to saturate the Montagnolo slope is high, the periods of greatest landslide risk will be those in which precipitation is consistently high, given heavy or persistent downpours after high antecedent rainfall conditions have maintained soil moisture at a high level. At Torrette, precipitation levels reach 100 mm per month in September and December, whereas at Ancona more than 190 mm falls in September and October, with slightly less in December (these are months when mean monthly temperature is falling from 18° to 16°C, but is still above the annual mean of 14° to 15°C). In spring and summer, the local climate is moderated by proximity to the sea and the lack of substantial topographic relief. Thus the autumn and winter are periods when rainfall is most likely to augment pore water pressure in slope soils, giving an immediate (as opposed to a long-term) cause of landsliding (Crescenti, et al., 1983).

Morphology and Processes of Landsliding

Colosimo (1982a) defined three types of geomorphological mass movement occurring at the Barducci-Montagnolo site during the years before the 1982 disaster: 1) superficial mud and debris flows took place during the season of high rainfall to a maximum depth of 5.0 m; 2) deep flows occasionally moved sediments to a depth of 10 m; and 3) lateral expansion of blocks bounded by faults caused creeping movement to a depth of 30 m. Thus the parameters of weight, and therefore the forces resisting overall landsliding, were continually changing position on the slope. Figure 5 (from

Figure 5

1982 ANCONA LANDSLIDE: SLOPE CATEGORY MAP



After Colosimo and Coppola (1979)

SLOPE ANGLE CLASSES:-

	$0 - 2.0^{0}$	0 - 3.5 %
	$2.0 - 5.2^{0}$	3.5 - 9.1 %
	$5.2 - 9.5^{0}$	9.1 - 16.6 %
	$9.5 - 14.0^{0}$	16.6 - 25.0 %
	$14.0 - 18.4^{0}$	25.0 - 33.3 %
	$18.4 - 26.5^{0}$	33.3 - 50.0 %
	$26.5 - 45.0^{0}$	50.0 - 100.0 %
	$45.0 - 90.0^{0}$	GREATER THAN 100.0 %

Colosimo and Coppola, 1979) shows that the form of the slope was complex, but with steep sections near the toe. Meardi and Marchini (1968) identified liquid mudflows, viscous or plastic flows, rotational sliding and soil creep at the site, but did not expect these various mass-movements to be necessarily coincident in time or location.

Ceretti (1974) stated that the upper (Montagnolo) and lower (Barducci) landslides were not connected and had shear planes extending to a depth of no more than 10 m. For the lower slide, shear creep was occurring as weathering progressively reduced the strength of materials and marine erosion gradually oversteepened the slope. Ceretti predicted the shear plane to be 4-8 m deep: at depths of less than 4 m cohesion successfully counterbalanced tangential forces, whereas deeper than 8 m normal forces associated with the weight of sediments mobilized sufficient friction to rule out sliding. He argued that the low stability at the base of the slope was the result of remoulding of sediments during past mass movements, reducing their shear resistance.

The actual morphology of the 1982 landslide is complex and, with respect to the position and form of the shear plane, is still the subject of debate at the time of writing. It is, however, clear that concerted movement has taken place over the whole area of the landslide, but involving different times, rates and directions of sliding, rotational as well as translational movements, and subsidence of blocks which have lost their confining lateral pressure in the downward movement of other segments of the slope. According to the configuration of small scarps and surface cracks, shear planes reach the ground surface in many places, and there are clearly multiple shearing planes which may or may not be connected at depth. Assuming, as seems highly probable, that shearing has taken place at great depth (perhaps even greater than 100 m) the landslide would fit into Varnes's classification (1978) as a combination of "rotational earth slump" and "translational earth block slide." This assumption will be further discussed below.

Proposed Causes and Remedies of the Slope Instability

Colosimo (1982a) attributed the Barducci landslide to slope hydrology disorders, uncontrolled urbanization, and both natural and human-caused erosion at the base of the slope. He regarded the upper Montagnolo landslide as the result of poor land management. Road building and urbanization concentrated slope wash and increased infiltration while disturbing the compactness of sediments, and deep ploughing of the non-urban areas also had an adverse effect on infiltration. Meardi and Marchini (1968) attributed soil creep and shallow surface mudflows at the site to the effects of wetting and drying cycles, with temperature changes, on the consolidation of swelling clays, and deeper mass movements to pore pressures. The causes of the 1982 landslide will be discussed in the next section.

Hypothesizing that only shallow failure would take place, Meardi and Marchini proposed that seven 4-5 m deep trenches, tapering upslope, be dug at the foot of the Montagnolo slope in order to drain it. The trenches would be orientated parallel or at 30°-40° to the direction of slope and would connect downslope to drainage wells. They would be filled with permeable materials such as cobbles and sand, and would interface with the wells through a barrier of porous brick. Constructing them at 30° to the slope would yield maximum interflow collection and the greatest possible slope drainage, but constructing them directly upslope would better help to preserve slope stability, by restraining the sediments at the slope foot.

In any case, the trenches and wells were never built (and nothing similar was constructed until after the 1982 disaster).

Ceretti (1974) made a series of five recommendations for preserving the stability of the Montagnolo slope:

1) Better measurement of stability-related variables, such as pore-water pressure, close to the urban areas of Posatora, Palombella and Borghetto.

2) Drainage and slope management of the Montagnolo (upper) landslide area.

3) Keeping all reverse-slopes dry and avoiding to construct steep embankments, with the spoil material abandoned at their base.

4) Monitoring rates of movement on the Barducci landslide, predicting the location of its shear plane and the forces involved in movement, as well as putting slope drainage schemes into operation.

5) Consolidating the basal road as a barrier to stop movement of the Barducci landslide, and consequent oversteepening of the slope above.

Interestingly, although it had not adopted any of these recommendations at the time of the 1982 disaster, the Comune of Ancona after the event considered building a substantial embankment for the Flaminia road and the railroad, in order to restrain the toe of the landslide. Measures had already been taken to control longshore drift, as the beach had receded 3 km during historical times, causing the base of the slope at Palombella and Borghetto to oversteepen. There are few indications as to whether such a project would stop the landslide from moving and the beach from cutting back. Thus, at the time of the 1982 disaster, virtually no steps had been taken to ensure the stability of the Montagnolo slope.

Although the actual failure mechanism of the landslide is unknown, the basic causes can be summarized. They consist of long-term and short-term causes (Costa and Baker, 1982). The long-term causes are:

1) Tectonics: intersecting faults, folds, fractures and lineaments.

2) Loss of the strength of sediments during weathering and deconsolidation.

3) The development of shear planes during past landsliding.

4) Deforestation and vegetation changes, with subsequent poor land management practices.

5) Poor slope drainage.

6) Increase infiltration caused by urbanization and mechanized farming.

7) Road building and associated disturbance of surface sediments.

8) Oversteepening of the slope by the actions of man, marine erosion at the base, or mudflows, landslides and soil creep on the upper sections.

Possible immediate causes include:

1) Seismic activity (which does not appear to be relevant in this case).

2) Increases in pore water pressure during saturation of the slope.

3) Liquefaction of sand lenses or layers at depth.

4) Progressive loss of stability following initial, small-scale landsliding (positive feedback).

The most important snort-term cause is likely to have been increases in pore water pressure following heavy rainfall which occurred in November 1982, but it is not possible to say which is the dominant long-term cause. It is most probable, however, that one such cause initiated a gradual decline in strength, and therefore of the factor of safety F for the slope, in much the same way as Karl Terzaghi postulated for the case of the Frank landslide in Alberta, 1903. The decline ended in 1982 when the Montagnolo slope reached the F value of unity, and failure was inevitable.

Thus, in summary, slope failure at Ancona was the result of several long-term causes, including increases in infiltration and decreases in soil strength caused by urbanization, and poor land management. The main short-term cause of collapse in the progressively weakened sediments was probably high pore water pressures during saturation of the slope. Movements were complex and probably both shallow and deep-seated translational-rotational in character. Much could have been done to prevent the progressive decline in the factor of safety towards its threshold value of F = 1. Drainage, infiltration control and more careful urban development might all have delayed, if not prevented, slope failure. Geomorphological aspects of the site, such as disturbance of the ground surface, indicated _a priori_ that shallow mass movement is endemic there: but prediction of a large-scale deep seated movement could only have been accomplished by testing the hypothesis that it could occur. Instead, investigators specifically discounted deep-seated movements or a unified shear plane extending the whole length of the slope, and thus had developed no procedure for predicting them. Had this not been so, the mode of slope failure--if not the exact time of occurrence--might have been foreseen.

ARCHITECTURAL OBSERVATIONS

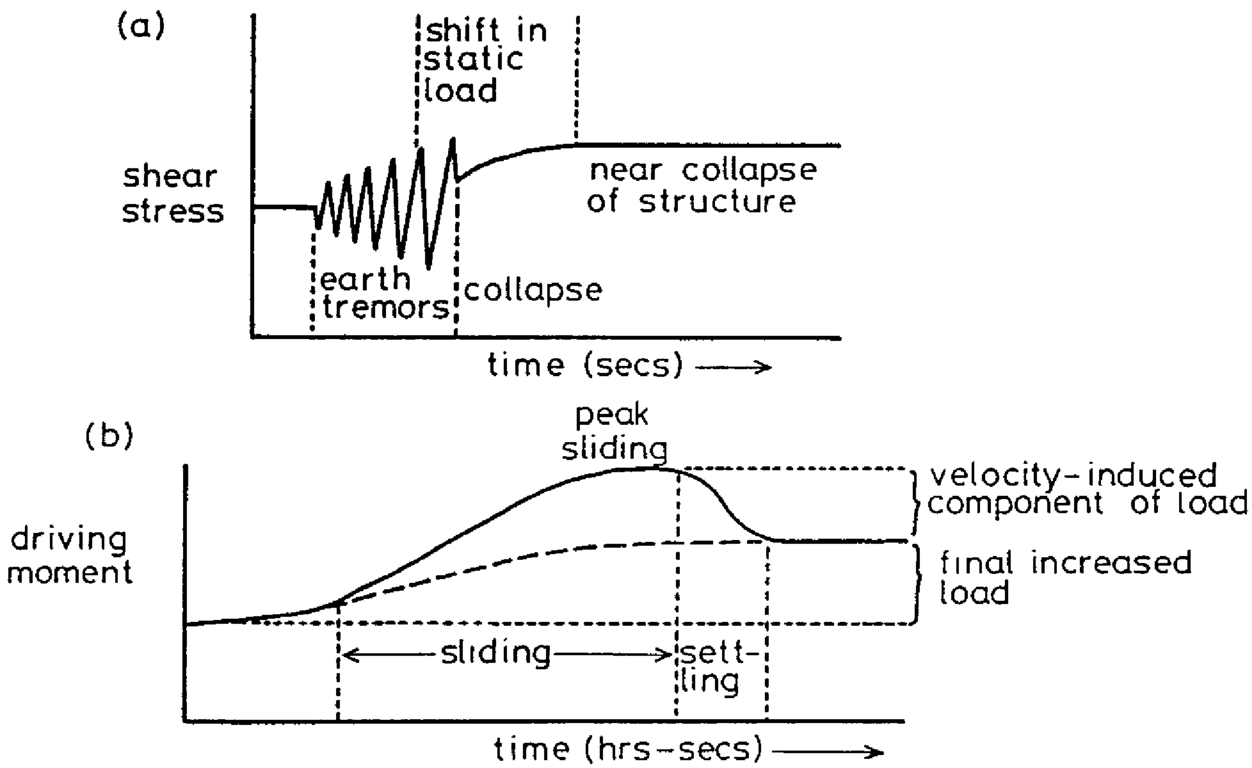
The following observations were made during my visits to the disaster zone during January and June-July, 1983. At Ancona damage to buildings and structures occurred almost entirely as a result of ground subsidence, although some structures were, conversely, raised relative to their original position. Subsidence is rarely a problem unless it involves differential movement of the ground: thus at Mexico City, for example, some buildings have undergone up to 9 m of subsidence without differential movement and still remain serviceable (Costa and Baker, 1981). Because of the complexity of patterns of ground movement, the Ancona landslide involved much differential subsidence, coupled with horizontal movements of between a few centimeters and several meters. Thus, many buildings were simultaneously slewed, tilted and subjected to differential movements under their foundations, which caused cracking. Very few structures collapsed: collapse was most common in retaining walls that were unable to withstand the increased pressure of soil and debris from upslope after they had suffered partial loss of foundational support.

Ferro-concrete buildings withstood the duress of the landslide better than either brick or stone buildings, probably because of having better rigidity at their bases and flexibility in their superstructures. Several three-story concrete buildings rotated out of the perpendicular (by up to 4.5°) without suffering notable failure of their superstructures, largely because they had rigid concrete pads as bases. In others the rectangular structure of columns and beams was distorted into a parallelogram since the joints between vertical and horizontal members were not strong enough to withstand the force applied by failure at the foundations. This caused windows to shatter, and often resulted in the collapse outwards of brick and plaster infill, which had not been strongly tied into the column-and-beam structure. Where infill did not collapse, it commonly cracked at its interface with the columns bounding it, or cracked in a unidirectional, diagonal pattern.

Many of the above observations are also true of earthquake damage, but there are fundamental reasons why landslide damage should be different. Earthquakes produce strong vertical and lateral stresses in buildings, resulting in compression and extension, and in sway. Shearing forces are usually concentrated at the base of the structure, where the combination of inertia produced by the building's weight and forces caused by ground acceleration is greatest. Once the shaking ceases, unless there has been foundational failure, the buildings will return to some semblance of static equilibrium load (Figure 6a).

On the other hand, a landslide involves the gradual build-up and maintenance of stresses--if differential subsidence occurs. The stresses caused by movement at less than, say, 3m/hr are unlikely to exceed greatly the stresses produced by gradual differential change in load (Figure 6b). Unless the building collapses, many of these stresses will remain. They will also greatly exceed earthquake stresses in duration (although not necessarily in magnitude). As in the case of earthquake damage, cracking tends to exploit lines of structural weakness in buildings, such as where masonry is poorly bonded or where walls are pierced by windows (which on an upper floor leave very little masonry under the eaves, resulting in cracking up to roof level). However, while X-shaped cracks often result from the alternating nature of stresses in the case of earthquakes, landslide-induced cracking tends to be diagonal and unidimensional.

Figure 6



HYPOTHESIS OF LOAD CHANGE ON STRUCTURES DURING (a) EARTHQUAKES AND (b) LANDSLIDES

Such cracking tends to pick out weaknesses in brick or stone masonry, but stress can also be sufficient to shear right through bricks, as happened at Posatora to a number of well-bonded, brick-built curtain walls. Differential subsidence in masonry or brick buildings can also cause distortion of door and window openings so that lintels come away from the wall above them and drop down a few centimeters on one side (usually the downslope side).

In several cases, differential subsidence caused buildings to behave quite differently from their surroundings. At Borghetto the "Adriatica" road was elevated by the advance of the landslide toe, and some buildings sank relative to the road surface by about 10 m. At Posatora, complex rotational movements meant that the direction and degree of both rotation and slewing differed from building to building. At and above the 80 m contour, there was often a tendency for buildings to rotate so that their upslope points were lower than their downslope ones, such that they tilted backwards relative to the slope. This was primarily caused where blocks of land dropped into the cavity left by faster-moving downslope blocks. A particularly notable case occurred in the center of the landslide, just above the Posatora-Torrette "post" road, south of Borghetto. There, a thick-walled farmhouse of rubble masonry has rotated backwards (i.e. sinking on its upslope side). This initially occurred at some time during the distant past, after which the doors and windows were re-set perpendicular in the walls, which continued to lean. Unfortunately, further rotation occurred during the 1982 landslide.

Below the 80 m contour, surface movement tended to be faster on the downslope side, such that buildings situated on small scarps rotated towards the landslide toe rather than its head. In any event, buildings rotated either when they straddled lateral "scarpettes" (which faced either upslope or downslope) such that one facade sank relative to the other, or when they were situated on rotating blacks of ground, especially where these were sinking into spaces left by faster-moving blocks on the downslope side. These points illustrate that the position of shear planes connecting with the surface is critical to the stability of buildings, which will rotate or fracture most if they straddle some lineament along which differential subsidence occurs.

The results of my full-scale architectural survey of the damage at Ancona are published in Alexander (1984).

A BACKGROUND OF GEOLOGICAL HAZARDS

The National Context

The Ancona landslide can be compared with other natural hazards in Italy in a number of ways. It can be seen that the 1982 disaster at Ancona is the largest and most expensive--although not the most extensive--catastrophe to have happened in the Marche Region for some decades. In other respects, however, it differs very little from the other recent landslide or earthquake disasters, at least in terms of the kind of problem created. Even a disaster of minor notoriety involves very high relief and reconstruction expenditure. In Italy exact data on the cost of preventing landslides and floods (by structural engineering or non-structural methods such as relocation) are rarely given, but it is likely that such costs would be lower than the cost of a cleanup and rehousing operation.

It is also difficult to dissociate the case of Ancona in 1982 from other Italian disasters, in that the relief and reconstruction funds come from the same source and require that local or regional politicians from each disaster-stricken community bid with the same members of central government. Indeed, this practice was formalized as long ago as 1918, when Law No. 445 of that year provided for _ad hoc_ state expenditure and the drawing up of a national list of comuni affected by disaster. It makes sense for both the local and national representatives of disaster-stricken communities to consider the overall demands for assistance as a complete picture, rather than as a series of individual cases. This would achieve a more rational apportionment of the limited funds that are available. It is thus encouraging to see that the government in Rome made some attempt to divide monies from the 1983 _serbatoio_ between Ancona and the other centers of need, such as Emilia-Romagna and the Umbrian earthquake zone. It is also encouraging that there is some sign of a national policy on land consolidation: Law No. 25 of 1980 gave a detailed national prescription for coping with the national erosion and landslide hazard, although the measures outlined are too few and will probably be too poorly financed to achieve much of a solution.

The Marsico Nuovo Landslide of February, 1983

Only eleven weeks after the Ancona disaster, serious landslide damage occurred in southern Italy at Marsico Nuovo (Basilicata Region). Contrasts and similarities between the two cases make it instructive to compare them.

In February of 1983 Pergola consisted of about 300 houses in which over 1,000 people were living. The area is situated on three geological formations, the first two of which are separated by N-S and E-W intersecting normal faults:

1) The landslide itself developed on Miocene (Langhian) deposits of the "Monte Sierio" formation (Valduga, et al., 1969). This heterogeneous unit consists of gravels, calcirudites with cobbles derived from the underlying limestone-dolomite, marls, greenish clays and occasional breccie.

2) This formation is bounded to the north, a short distance from the landslide, by the outcrop at Monte di Tigliano (1,078 m) of the "Galestrine Flysch" unit, of apparent Lower Cretaceous-upper Jurassic age. It consists of shaly clays, marls (galestri) with marly-siliceous limestone and breccia intercalations, and isolated occurrences of calcarenite and conglomerate.

3) To the E and NE of Pergola there are sheets of colluvial debris, arranged with the distal end towards the hamlet, representing material derived from Monte Cugnone (1,160 m).

The 1983 landslide developed on units of sedimentary rock that are heterogeneous and highly variable in their degree of cohesion and cementation. They are bounded by faults which are partly obscured under slope-wash deposits.

The Event

Landsliding at Pergola in the Comune of Marsico Nuova took place in the afternoon and evening of February 28, 1983, setting about 3 km² of soil in motion at speeds of 1 m/day. Although meterological data are presently not available, it seems clear that high intensity rain was the immediate cause through the pore water pressure mechanism. Evacuation of damaged homes took place at the following rate:

Monday, 28 February	30 Homes	c. 150 people
1 March	40	196
2	54	
3	58	
4	68	224

The number of homeless people is not perfectly correlated with the number of homes that were officially certified by the comune as unfit for use, as eight dwellings were the properties of migrant families, who were not occupying them at the time. About 30 livestock stalls were damaged, as well as 42 feedstock repositories; roads, power lines and a water main were also severed. Owing to the relative slowness of onset of the phenomenon, deaths and injuries did not occur.

The Response

Almost immediately, 38 police, 54 carabinieri (national guardsmen), 22 firemen and 15 state foresters were drafted into the emergency area. The Prefecture of Potenza sent 24 trailers (a remnant of the 1980 earthquake disaster), which were promptly allotted to 96 of the homeless, while other victims found lodgings with relatives and friends. Indeed it is reported (Il Tempo, Rome, March 3, 1983) that the trailers were not used as a primary shelter, merely as dormitories, and the reason is most probably that the homeless were unwilling to depend too readily on state aid or develop too clear a separate identity as "victims" within their own community.

The blow to animal husbandry, on which the local economy greatly depends, was severe, and 400 head of sheep and goats had to be transferred to folds owned by the nearby Comuni of Grumento Nova and Villa d'Agri (respectively 10 and 20 km to the SE). Geological and technological assessment of the site were rapidly made, and some demolition of badly damaged buildings took place during the first few days of the emergency. Fresh water was temporarily supplied by two mobile tankers and it took about a week to restore electricity lines crossing the landslide area (the water main was, according to the Agri Valley Land Reclamation Consortium, too seriously damaged to repair in such a short period of time). Local quantity surveyers estimated the cost of repairing roads and utilities as 20 billion lire ($12.89 million) although it is not clear how realistic a figure this is. Damage to buildings is estimated at 10 billion lire ($6.45 million), again with an unknown level of accuracy.

Two members of the Italian government with constituencies in Basilicata took an immediate interest in the disaster. The Undersecretary of the Interior visited the landslide on March 4, 1983, while the Minister of Foreign Affairs raised the matter at a cabinet meeeting. However, there is no indication that either move had any positive result, other than to reassure local Christian Democrats and provoke their adversaries. Meanwhile, the Mayor of Marsico Nuova sent an emissary to the government in Rome to negotiate for emergency relief funds. The Minister of the Interior granted 100 million lire ($64,500) for the temporary relief of homelessness caused by the landslide, while the Minister of Civil Protection advised that more funds could be obtained if the Comune were to apply for insertion into the list of comuni to receive government help with reconstruction following the 1980 earthquake. These comuni are receiving financial aid under appropriations from the budget made with Law No. 219 of 1981, the southern Italian 1980 earthquake reconstruction law.

Criticism

Local trade unions were quick to point out the inadequacy of land stabilization policies in Basilicata. A plan of reforestation, slope terracing and other measures exists, with an annual budget financed in part by the European Economic Community Development Fund, and by regional and national government funds. However, the budget for 1983 does not include sufficient funds to combat the landslide hazard effectively--given that each of the ubiquitous slope instability phenomena requires a marked concentration of expenditure, usually of millions of lire per hectare. Furthermore, basic survey research into local mass movements is incomplete, and neither is there any concerted regional plan for their amelioration. Strangely, although the connection between intense rains and geomorphic mass movement was clear to all who were involved in the landslide, the fact that the headscarp area above a sizeable settlement was nourished by artesian water seems to have passed without comment.

Comparison with the Ancona Disaster

The Marsico Nuovo disaster brought into play a pattern of response that had become familiar in countless other landslide areas since in the early 1900s the geographer Roberto Almagia identified 700 damaging landslides on the Italian peninsula (Almagia, 1907-1910). It also demonstrated once again that the magnitude of hazard, together with associated costs, has grown much faster than government procedures to cope with it have evolved. The pattern of response, with all inherent faults, can be codified as follows:

1) A predictable geophysical hazard was ignored, despite warning signs (minor landsliding) some years before its main impact.

2) No strategy of prior preparedness was developed.

3) Urban environments co-existed tranquilly with the hazard, unprotected.

4) Sudden disaster caused mass suffering and made national news.

5) The estimated cost of damage was high.

6) Funding and hazard amelioration procedures were found to be inadequate.

7) The regional and national governments expressed an interest in the disaster.

8) Local government sent a representative to negotiate with high levels of government for financial aid.

9) Immediate aid fell short of the estimated need by an order of magnitude.

10) Long-term aid involved delay and complex negotiations.

11) People rendered homeless by the disaster must endure a long-term temporary solution.

12) In response to the cumulative effect of this and other disasters, national and regional plans of logistical and financial preparedness were belatedly drawn up, but they lagged the evolving hazard situation by a substantial margin.

In areal terms, the Marsico Nuovo landslide was approximately the same size as its counterpart at Ancona (although it was probably much shallower, and therefore smaller in terms of volume). Computing a series of ratios for the two disasters (Marsico Nuovo:Ancona), one obtains a ratio of relative costs of between 1:23 and 1:35, depending on the magnitude of damage estimates, but showing in any case that a considerably smaller value-amount of damage was caused at Marsico Nuovo. The ratios of homelessness and the number of emergency personnel involved in the clean up operation are each 1:16.3, indicating that the human dimension at Marsico Nuovo was proportionately greater than at Ancona. However, in terms of the proportion of needed relief funds that was immediately granted by central government, the situation is rather different. Ancona managed to obtain from central government 15.7 % of the cost of its landslide in primary aid, but Marsico Nuovo could only obtain 0.5 to 1.0 %. Although cost estimates at Marsico may be exaggerated, it is clear that the Marsico Nuovo disaster carried less political weight--and therefore valued less in relief money--than the Ancona disaster.

Thus one cannot say that the Marsico Nuovo disaster was a miniature version of the Ancona emergency, for the impact, effect and response associated with such disasters all vary in a non-linear way with the size of event. As a generalization, it may be that larger landslide disasters in Italy involve less over-estimation of their consequences and proportionally better response on the part of the authorities, while smaller disasters provoke more of an under-response.

CONCLUDING REMARKS

It is clear that the Ancona landslide could have been predicted and its worst consequences prevented. Apart from any political reasons why this did not happen, or any question of corruption or negligence, the disaster has shown that procedures for defining and coping with natural hazards in Italy need to be clarified and made more systematic. Given that disasters on the scale of the Ancona landslide occur frequently and that much of the nation is menaced by natural hazards, it is essential that better procedures be developed to cope with environmental disaster. There are five main sources of conflict which need to be resolved by clarifying the national policy. All of them are illustrated by problems related to the catastrophe at Ancona:

1) The relative proportions of national resources to be devoted to environmental consumption (i.e. utilizing the environment for benefit or profit) and environmental protection need to be clarified.

2) Procedures need to be worked out to define the relative levels of financial responsibility of local, regional and central government with respect to both hazard prevention and disaster relief. This is also true of the scientific and technical investigations that must necessarily precede hazard reduction schemes. At all three levels sources of funding must be identical and earmarked in order to mitigate future hazards and disasters. The guiding principle is always that prevention is better than cure, and is usually much cheaper.

3) The level of individual, or corporate, responsibility for disaster effects needs to be specified, rather than simply assuming that the various levels of government are responsible. In Italy, for example, no steps have ever been taken to prescribe the degree to which an individual is responsible for the safety and soundness of his or her own home. National disasters tend to provoke immediate underwriting by the government, even though the proportion of Gross National Product that can be utilized is usually inadequate to cover the damage. Giving some responsibility back to the individual would encourage better personal preparedness--for example, better maintenance of buildings, which has proved to be a critical

factor in earthquake damage resistance. Incentives, such as government sponsored hazard insurance (with premiums payable by the individual who is at risk) and property improvement loans or grants, are necessary.

4) Benefit-cost ratios need to be worked out for schemes of defense against hazards and compared with the probable cost of disaster relief if nothing is done until disaster strikes. Nationally, less emphasis should be given to personal consumption of goods and more emphasis to cooperative schemes of environmental defense. This is especially true in that natural disasters are capable of destroying resources that are precious yet irreplaceable. For example, social cohesion in the small communities of rural Italy often depends to a greater or lesser extent on the distinctive and historical character of the environment. If this is jeopardized or destroyed by earthquake, flood or landslide, the social community can begin to disintegrate, yet many such communities are at present defenseless against a very real threat from extreme natural events.

5) It is essential that a distinction be made between predicting an extreme event, such as a damaging landslide, and warning the affected population or taking other avoiding action. At Ancona, as in other Italian disasters, there was no "chain of command," formalizing who should be responsible for predicting the disaster and who should give warnings or find some way of absorbing the impact. It is only a matter of time before the next disaster happens in Italy in general and Ancona in particular. While it may not be possible to avoid future disasters, their impact could be significantly reduced if both scientists and governments had clearly defined, separate, but interacting, roles to play and responsibilities to assume.

At Ancona some attempt was made to predict disaster, and modest schemes of hazard prevention were designed. These were largely ignored by the city council, who nevertheless reacted rapidly to the disaster when it occurred. Individual responsibility for the damage was waived and government funds were substituted; what American commentators sometimes describe as "forgiveness money" was handed to the occupiers of the stricken hazard zone. Prior awareness of the hazard among politicians and citizens was low and discouraged, while geologists showed a reluctance to participate in the political aspects of hazard prediction (but were inevitably drawn into the political wrangle after the catastrophe had occurred). At the time of writing the long-term funding for disaster relief and reconstruction in Italy is uncertain, but as government response to the disaster is basically *ad hoc*, the lesson of previous disasters is that payment will almost certainly be delayed (Geipel, 1982), engendering further misery among disaster victims.

Finally, it is important to consider whether the pattern of disaster response in Italy is set, or whether it is changing in reaction to the repeated demands for relief. Despite the frequency of disasters and the similarity of relief needs after each one, there has been little progress towards a unified and effective national policy against natural disasters. The Italian approach is still *ad hoc*, fragmentary and lacking in substance. The creation of a Ministry of Civil Protection, although a formal recognition of the problem, can be viewed as little more than an attempt to reduce the amount of legislation needed, and the amount of conflict involved, in granting relief funds to stricken communities. Many of the fundamental issues, such as who is ultimately responsible for the consequences of disaster, have never been settled or even aired in the national arena. Funds for disaster relief are still only a fraction of the costs of disasters, yet individual victims or survivors are not told that they are responsible for the balance of costs, so that there is a break in the chain of responsiblity and accountability. As the cost of the Italian national of natural hazards and disasters is increasing, and there are strong probabilities of high future death tolls, it is essential that the issues of responsibility, preparedness and prevention be tackled at the earliest opportunity.

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APPENDIX I

NOTES ON POLITICAL GEOGRAPHY

Basic administrative divisions in Italy and the disaster area:

comune	Township, municipality (Ancona, pop. 108,466, December 31, 1978) Comune di Ancona--Ancona City Council.
frazione	Outlying settlement, not the principal nucleus of a comune, e.g. Torrette is a frazione of Ancona Comune.
provincia	province: 95 in Italy, 4 in the Marche: AN Ancona, MC Macerata, AP Ascoli Piceno, PS Pesaro-Urbino.
regione	region: 20 in Italy: Regione Marche: 9,694 km², pop. 1,409,845 (145 persons/km²).

ABBREVIATIONS

Political Parties

DC	Democrazia Cristiana	Christian Democrats
PCI	Partito Comunista d'Italia	Communists
PDUP	Partito d'Unita Proletaria	Proletarian Unity Party
PRI	Partito Repubblicano d'Italia	Republicans
PSDI	Partito Social Democratico d'Italia	Socialists

Ministries and Public Bodies

ANAS	Azienda Nazionale Autonoma delle Strade	State Roads
CNR	Consiglio Nazionale delle Ricerche	National Research Council
FS	(or FFSS)Ferrovie dello Stato	State Railways
LLPP	Ministero dei Lavori Pubblici	Ministry of Public Works
MPC	Ministero della Protezione Civile	Ministry of Civil Protection
PTT	Poste e Telegrafi	Post Office and Tele-communications
RAI	Radiotelevisione Italiana	State Broadcasting Corporation

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