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ACRONYMS AND ABBREVIATIONS

ADB	Asian Development Bank
AQU	L'Aquila. Italy (MedNet Station)
CARP	Comprehensive Agrarian Reform Program
COSPEC	Correlation Spectrometer
BNI	Bardonecchia, Italy (MedNet Station)
BSWM	Bureau of Soils and Water Management
DENR	Department of Environment and Natural Resources
DHA	Department of Humanitarian Affairs
DPWH	Department of Public Works and Highways
ESCAP	Economic and Social Commission for Asia and Pacific
FAO	Food and Agriculture Organization
GNP	Gross National Product
GDP	Gross Domestic Product
IBRD	International Bank for Reconstruction and Development
IDNDR	International Decade for Natural Disasters Reduction
ING	Istituto Nazionale di Geofisica (Rome, Italy)
JICA	Japan International Cooperation Agency
MedNet	Mediterranean Network
NASA	National Aeronautics and Space Administration
NEDA	National Economic and Development Authority
NGO	Non-Government Organization
NEIC	National Earthquake Information Center
PAGASA	Philippine Atmospheric, Geophysical, Astronomical Services Administration
PAWB	Parks and Wildlife Bureau
PHIVOLCS	Philippine Institute of Volcanology and Seismology
SAR	Search and Rescue
SEASEE	Southeast Asia Association of Seismology and Earthquake Engineering
SPT	Standard Penetration Test
UNDP	United Nations Development Programme
UNDRO	United Nations Disasters Release Operations
VSL	Villasalto Italy, (MedNet Station)
USGS	United States Geological Survey
WHO	World Health Organization
WMO	World Meteorological Organization

GLOSSARY

Allophane An amorphous hydrated allumino-silicate mineral present in clay soils.

Andesite A fine-grained effusive rock mainly made of andesine and mafic minerals.

Astenosphere The plastic layer of the earth immediately beneath the lithosphere.

Astrobleme An ancient impact crater from the collision of a meteorite on earth.

Basalt An effusive dark rock in a glassy or fine-grained mass, mainly composed of calcic plagioclase and pyroxene, with or without olivine.

Basement rock Igneous or metamorphic rock complex, usually unconformably overlain by sedimentary rocks.

Batholith A large plutonic rock mass intruded as a result of the fusion of older rocks and mainly composed of granodioritic and quartzo-monzonitic minerals.

Benioff zone The inclined plane descending beneath the continent (as a result of the subduction process) where earthquake foci cluster.

Calc-alkaline Igneous rocks with the weight percentage of silica between 56 and 61 in the presence of an equal percentage by weight of Calcium monoxide and Potassium plus Sodium monoxides.

Conglomerate A sedimentary rock made of cemented, coarse-grained, rounded and gravel to pebble-sized rock fragments

Cost of the damage The overall cost of the damage induced by a disaster. It includes the cost of the damage generally affecting the human environment (houses, infrastructure and working activities) plus the cost which can be attributed to the destruction of the physical and biological environments. The latter costs (due to various types of environmental impact) are more difficult to evaluate and, thus, often inaccurate. See also economic losses.

Crustal plates Blocks 60-100 km thick forming the earth's crust or lithosphere and usually named macro or micro plates based on their size.

Cyclic ground shaking The motion associated with earthquakes and consisting of cycles of displacement of alternating direction.

Cyclone An atmospheric violent phenomenon due low-pressure conditions during which the air rapidly moves in a circular direction.

Dacite An effusive, fine-grained, rock made of plagioclase, quartz and piroxene (it generally corresponds to the composition of andesite in the domain of intrusive rocks).

Differential settlement The settlement of a foundation with different magnitude between various parts of the structure. The differential settlement can create greater distressing effects on the superstructure of a foundation than the total settlement.

Dolerite An intrusive rock with a composition similar to that of basalts.

Earthquake generator or source zone A geologic structure along which earthquakes can be generated.

Economic losses Losses due to natural disasters and generally affecting man, man-made structures and human activities. Economic losses do not include the damage to the environment, as for example the destruction of a forest and the life in it during a volcanic eruption. See also the cost of damage.

Effusive rocks Igneous rocks deriving from the cooling of lavas ejected at the surface of the earth.

Environment The complex of conditions (physical, chemical, biological, social, cultural, political and economical) that characterize a certain area and influence life and development of local inhabitants.

Epicenter The point of the surface of the earth directly above the focus of an earthquake.

Fault A fracture of the earth's crust along which relative displacement has taken place.

Flexible pavement A road pavement made of flexible layers (natural granular materials or crushed rock fragments either untreated or bound with asphalt). The definition is used in contrast with rigid pavements, which are made of reinforced concrete slabs.

Focal mechanism The mechanism describing the block's motion generating an earthquake.

Focus (or hypocenter) The point from which seismic waves are generated during an earthquake. Directly above the focus on the ground surface the epicenter is located.

Granite An intrusive, coarse-grained, plutonic rock mainly made of quartz, alkali feldspar and sodic plagioclase. Granitic rocks are the major constituents of batholiths which are huge plutonic bodies resulting from the cooling of magmas intruded into pre-existing rocks.

Granodiorite An intrusive, coarse-grained, rock mainly made of quartz, plagioclase and potassium feldspar.

Ground rupture The rupture of the ground surface associated with an earthquake.

Habitat An area and its local conditions with the capability to sustain life needs of a biological population.

Hypocenter See focus.

Hurricane See tropical cyclone.

Ignimbrite An effusive rock associated to the deposition of volcanic ash, lava and dense clouds of high-temperature volcanic glass.

Internal friction The mechanical resistance of contiguous soil particles to relative motion.

Intrusion The emplacement of solid or molten rock in preexisting rocks.

Intrusive rock Igneous rocks deriving from the cooling and consolidation of magmas beneath the earth's surface.

Joint (or discontinuity plane) A plane (often a family of planes) which parts the rock. Other discontinuity planes of the rock mass are faults and bedding planes.

Lahars Indonesian term for mudflows defining the fluid mix of water and volcanic ejecta moving along the slopes of a volcano and either triggered by heavy rains after an eruption or by steam condensation during an eruption.

Lateral spreading The horizontal movement of sediments. The phenomenon, which can be triggered in various ways, has destabilizing effects on the foundations of structures.

Latite An igneous effusive rock made of a glassy groundmass with crystals of plagioclase and potassium feldspar.

Lithosphere The 60-100 km thick layer of the earth's crust floating over the astenosphere. The lithosphere is composed of some big plates and a number of micro-plates either colliding, stretching or separating.

Mafic Igneous rocks mainly composed of ferromagnesian minerals.

Magma Mobile molten rock with the capability of extrusion or intrusion and source material of igneous rocks after solidification.

Magnitude of an earthquake The concept, which was developed by the seismologist C.F. Richter to measure of the strength of earthquake, involves the strain energy released during such a phenomenon, based on seismographic data.

Mantle The zone of the earth between the crust and the core: the outer zone of it (upper mantle) is named astenosphere.

Metamorphism Process of alteration of solid rocks mainly due to high pressure and heat.

Meteorite Mass of matter from the outer space that struck the earth's surface.

Morpho-tectonic units Geomorphological units mainly resulting from the action of tectonics.

Mudflow General term used to express the flowing of mainly fine-graded materials and water along a streambed. It is often used as synonymous of lahar.

Ophiolite A group of igneous rocks (mafic and ultramafic) previously part of the oceanic crust.

Pelite A sedimentary rock made of fine sediments. The term is often used as synonymous of mudstone.

Phreatomagmatic eruption A volcanic explosion rich in steam and gases. It occurs when magma gets in contact with ground water or when marine water penetrates along fractures reaching the volcanic chamber.

Physiography A description of landforms.

Plagioclase A group of minerals whose composition spans from albite to anorthite.

Plate tectonics A theory of earth dynamics based on the motion of lithospheric plates floating on the astenosphere.

Pluton An igneous rock body resulting from the cooling of magma intruded into preexisting materials. The term plutonic rocks is often used as a synonymous of intrusive rocks.

Porphyrite Igneous rock with a glassy or fine-grained rockmass and coarse crystals.

Pyroclastics Volcanic material ejected during the explosive phase of a volcanic eruption.

Regolith Incoherent surface material of different origin overlying the bedrock or in situ soils.

Rejuvenation The enhancement of the erosive activity of a stream as a result of tectonic upheaval or a drop of sea level.

Reverse polarity underthrusting A case of convergent subduction. It happens in the Philippines where the South China Sea Plate is subducting eastward and the Philippine Sea Plate westward. both descending underneath the Archipelago.

Rhyodacite Effusive rock (equivalent in composition to the intrusive term granodiorite) made of quartz, plagioclase and biotite.

Rigid pavement See flexible pavement.

Sandstone A sedimentary rock mainly made of cemented medium-grained quartz grains.

Schist A medium-coarse grained and foliated metamorphic rock originated by dynamic methamorphism and mainly composed of quartz and muscovite.

Sedimentary rocks Rocks resulting from the accumulation and consolidation of mainly waterborne sediments. The family, which includes sound rocks (limestones, sandstones), cemented sediments (conglomerate, mudstones) and wind-blown volcanic ejecta (tuffs), is characterized by a layered structure.

Seismic (refraction, reflection) profiles Seismic prospecting is a geophysical method based on the analysis of elastic waves generated through the explosion of dynamite or the impact of a falling mass on the ground surface. The arrival times of elastic waves generated at a fixed point are measured at increasing distances, recorded and analyzed. By combining geologic information and seismic data a geological cross-section of the investigated profile is derived. Refraction and reflection profiles are different types of seismic investigation, depending on the distance between consecutive receivers (geophones) and the type of the array.

Shales A sedimentary laminated rock mainly originating from the consolidation of clay.

Shear Zone A tabular zone where the rock has undergone crushing during deformation and shearing.

Silt A small particle (with a diameter ranging between 0.06 and 0.004 mm) forming numerous sedimentary rocks.

Strike-slip motion The relative motion of rock blocks parallel to the fault strike.

Subduction The process by which oceanic crust descends beneath a nearby plate. Sea also Benioff Zone.

Tephra A general term for the pyroclastic materials ejected from a crater during an eruption.

Thyphoon A tropical cyclone.

Tonalite An intrusive rock made of quartz, plagioclase and horneblende.

Tornadoes A violent storm common in W Africa and U.S.

Transcurrent Fault A fault in which the two blocks shift laterally one past the other.

Transform fault A strike-slip fault typical of mid-oceanic fractures and along which the ridges are offset.

Trench A deep, steep-sided, narrow and elongated sea-floor depression usually exceeding 6 km and marking the zone between the continental margin and the abyssal plains.

Tropical cyclone Tropical cyclones, typhoons, or hurricanes are the names given to the same phenomenon in different parts of the world. They are weather systems with strong winds that circulate anti-clockwise around a low-pressure area in the northern emisphere and clock-wise in the southern emisphere. They are capable of causing massive destruction in three ways: by high winds, heavy rainfall causing inland flooding and storm-surge flooding (Source: Disaster Mitigation in Asia and the Pacific, ADB, 1991a).

Trough A flat-floored depression shallower than a trench.

Tsunami A huge marine wave produced by a volcanic eruption, earthquake or undersea avalanche.

Tuff A pyroclastic deposit made of volcanic ash and dust.

Typhoon See tropical cyclone.

Unconformity A gap in the stratigraphic sequence. Uncomformably is said of the geologic condition of layers whose contact is characterized by an unconformity.

Weathering The group of processes affecting the rocks as a result of their exposure to the atmosphere.

SUMMARY OF THE BOOK IN ITALIAN

Il libro «Geological Disasters in the Philippines» trae spunto dalla presenza dell'Autore nell'arcipelago delle Filippine durante il terremoto del 16 Luglio 1990 e la eruzione vulcanica del Pinatubo nel Giugno 1991.

L'aspetto scientifico più importante di questi fenomeni geologici è lo stretto rapporto di causa ed effetto tra terremoto ed eruzione. Per quanto concerne invece le conseguenze immediate dei due disastri e gli effetti primari e secondari, a medio e lungo termine, gli eventi geologici degli anni 1990-91 rappresentano un caso unico di successione di calamità con profonde implicazioni dovute alle interazioni tra tettonica e clima e tra questi ultimi e lo sviluppo umano.

La collisione tra lo scudo euro-asiatico e la placca del Pacifico è all'origine del terremoto del Luglio 1990 in Luzon. La tettonica delle Filippine può essere sinteticamente descritta come: a) una doppia subduzione dei fondi oceanici ad Occidente ed Oriente del Paese che si immergono in convergenza sotto l'arcipelago dando luogo a numerosi terremoti, e, b) lo scorrimento orizzontale lungo la faglia trascorrente denominata «Philippine Fault». Quest'ultima è considerata come il meccanismo attraverso il quale viene parzialmente assorbito l'accorciamento crostale prodotto dalla doppia subduzione. Una parte dell'accorciamento si traduce, infatti, nel continuo innalzamento della catena montuosa di Luzon Occidentale, denominata Cordillera Central. L'attiva erosione presente in quest'ultima, i versanti molto acclivi e l'attivo trasporto solido durante la stagione delle piogge sono in armonia con il quadro tettonico della zona.

Il terremoto che colpì l'isola di Luzon il 16 Luglio 1990 (epicentro vicino Rizal, Magnitudine 7.7 Richter ed ipocentro a 24.8 km di profondità) produsse una vistosa rottura del terreno per circa 120 km con uno scorrimento orizzontale massimo di 6.2 m ed un verticale variabile da 0.5 a 2.2 m. Rotture altrettanto estese si verificarono ad Ovest della rottura principale ma con scorrimenti minimi. Il terremoto produsse una liquefazione a livello regionale (1000 km^2) nella piana denominata Central Plain ed un numero elevatissimo di frane superficiali nei rilievi della Cordillera Central e delle Caraballo Mountains. Parte del Central Luzon e la zona ad Ovest e Nord della rottura principale furono interessate dai distruttivi effetti del terremoto. Strutture di ogni tipo furono irreparabilmente danneggiate (palazzi, strade, ponti etc.) mentre le vittime furono valutate in 1666, oltre ad alcune migliaia di dispersi.

Il terremoto fu seguito da uno sciame sismico che si protrasse per alcuni mesi con intensità massima tra il Luglio ed l'Ottobre del 1990. Durata e sviluppo dello sciame, ubicazione e concentrazione degli epicentri furono attribuiti alla vasta riorganizzazione dei blocchi crostali di Luzon indotta dal terremoto del Luglio 1990.

Mentre lo sciame sismico si spostava in prevalenza verso Nord, nell'Aprile del 1991 si verificava la prima esplosione del Pinatubo. Frattanto si era anche attivato in Giappone Monte Unzen, probabilmente anche esso a seguito della rottura della Faglia della Filippine, fenomeno quest'ultimo certamente tra i più grandi di questo secolo e forse di questo millennio.

La eruzione del Pinatubo, che è ubicato nel Central Plain 110 km a NW di Manila e 90 km circa ad W dell'epicentro del terremoto del Luglio 1990, produsse ulteriori danni e morti nella zona. Con la fase parossistica della esplosione a metà Giugno 1991 il vulcano depositò circa 7 km cubici di prodotti piroclastici intorno al cono e ne disperse alcuni nell'atmosfera. Il danno derivante dalla deposizione della coltre di ceneri fu gravissimo per le cittadine ed i centri abitati della zona. La gran maggioranza delle case in Filippine sono costituite da strutture leggere i cui tetti devono solo proteggere dalla piog-

gia, pertanto il peso delle ceneri provocò la distruzione di numerose abitazioni. Tuttavia anche strutture più robuste ne risentirono ampiamente. La coltre di ceneri provocò la immediata distruzione dei raccolti e la paralisi delle attività agricole ed industriali portando al collasso l'economia locale.

Durante la fase critica della eruzione (12-15 Giugno 1991) iniziarono le piogge monsoniche. Queste ultime, come era logico attendersi, produssero la fluidificazione del manto di ceneri provocando vistosi «lahars», parola indonesiana con la quale vengono chiamate le colate di fango che si attivano a seguito della mobilizzazione, da parte di piogge intense, di prodotti piroclastici da poco depositati. I lahars, incanalandosi lungo i fiumi che radialmente si diramano dal cratere del Pinatubo, portarono a valle quantitativi enormi di sedimenti (oltre mezzo km cubico/anno nel periodo 1991-93), con ulteriori danni per l'agricoltura e con una vistosa modifica della rete idrografica di valle. Mentre il danno maggiore della coltre di ceneri si era attestato nel raggio di 20-30 km dal cratere, i lahars portarono ulteriore distruzione fino a 50 km.

Concludendo, i due disastri in successione ed i fenomeni ad essi legati, in parte esasperati dalla estesa deforestazione della zona, produssero danni enormi di fatto portando l'economia dell'intero stato delle Filippine a crescita zero dopo alcuni anni di ripresa.

Il libro dedica una certa attenzione al problema dei disastri naturali a livello globale nel primo capitolo. Il secondo ed il terzo capitolo sono rispettivamente dedicati ai disastri che comunemente colpiscono l'arcipelago ed alla geologia e tettonica delle Filippine. I capitoli dal quarto all'ottavo riguardano in successione il terremoto del 1990, la liquefazione nel Central Plain, le frane nelle catene Cordillera Central e Caraballo Mountains, lo sciame sismico e la eruzione del Pinatubo. Gli ultimi due capitoli sono dedicati al danno economico arrecato alla economia delle Filippine (Capitolo 9) ed agli insegnamenti appresi dai due fenomeni, nonché ad alcuni suggerimenti (Capitolo 10).

THE GEOLOGICAL TIME-SCALE

Eras	Periods		Epoches	
Cenozoic	Quaternary 1.8 my - today		Holocene *	
			Pleistocene	
	Tertiary 65 - 1.8 my **		Pliocene	3.2 my
			Miocene	19 my
			Oligocene	14 my
			Eocene	16 my
			Paleocene	9 my
Mesozoic 225-65 my	Cretaceous	80 my		
	Jurassic	45 my		
	Triassic	35 my		
Paleozoic 570-225 my	Permian	55 my		
	Carboniferous	65 my		
	Devonian	50 my		
	Silurian	35 my		
	Ordovician	70 my		
	Cambrian	70 my		

* Holocene 15,000 years
** my million years.

EARTHQUAKE SOURCE ZONES OF THE PHILIPPINES

from S.S. Su (1988), Seismic Hazard Analysis for the Philippines, Natural Hazards 1. Reprinted by permission of Kluwer Academic Publishers.

Fault Zones 1 to 8

Zone 1. Focal mechanisms for Zone 1 are predominantly of the thrust type while those of Zone 4 (which is contiguous to 1A and 1C) are generally of the strike-slip type (Lewis and Hayes, 1983, citing Cardwell et al., 1980; Seno and Kurita, 1978; Fitch, 1972; Katsumata and Sykes, 1969). Negative free-air gravity anomaly in 1A and 1C is interpreted as indicating crustal downwarping and a precursor to rupture (Lewis and Hayes, 1983). High seismicity, focal mechanism solutions, and seismic sounding profiles show Recent (Pleistocene) to Present underthrusting in 1C (Cardwell et al., 1980). However, the absence of active volcanism, and the lack of a well-defined Benioff zone and of earthquakes deeper than 200 km show that current subduction is young.

Zones 2 and 3. The two zones comprise the Philippine Trench (2B and 3B) and its Quaternary volcanic forearc (2A and 3A) (Divis, 1980). North latitude 12 degrees separates Zone 2 from Zone 3. Zone 2 has a poorly developed Benioff zone that dips westward to a depth of about 100 km (Cardwell et al., 1980). Zone 3 has a better developed Benioff zone that extends to a depth of about 200 km south of Samar, as shown by intermediate earthquakes. Considerably deeper earthquakes are found east of Mindanao and southward to Talaus Island. The relative shallowness of the dipping lithosphere in Zones 2 and 3, together with the lack of significant Quaternary volcanism in Eastern Mindanao and Samar (Lewis and Hayes, 1983), coupled with the evidence from seismic reflection profiles showing no well-developed accretionary prism in the forearc region (Hamilton, 1979; Karig, 1975; Karig and Sharman, 1975) strongly suggest that the present subduction episode may have begun only in Quaternary time, and is still propagating southward to the east of Talaud and Halmahera islands (Cardwell et al., 1980; Murphy, 1983).

Zone 4. Zone 4 is the double forearc associated with the Manila Trench which lies west of Luzon (Lewis and Hayes, 1983; Cardwell et al., 1980; Karig, 1973). 4B and 4D are the 'inner' volcanic forearc while 4A and 4C make up the 'outer' nonvolcanic forearc. Seismicity is much higher in 4C than in 4D; also relatively higher in 4 A than in 4B. 4B and 4D are marked by presently active volcanoes and Quaternary cones (Cardwell et al., 1980). Focal mechanism solutions of earthquakes in the North Luzon Ridge (4B) are predominantly of the strike-slip type. Some of these are left-lateral and some right-lateral.

Zone 5. Zone 5 is the Manila Trench. It has a Benioff zone that dips 40 degrees eastward. The dip angle increases to almost 90 degrees as one proceeds southward to Manila Bay. The Benioff zone extends to a depth of about 200 km (Hayes and Lewis, 1984). South of latitude 13 degrees, the Manila Trench changes its trend from north-south to northwest-southeast, and curves towards the Mindoro Strait. This is believed to be due to the collision of the subducting lithosphere with the North-Palawan (Calamian) micro-continental block (Lewis and Hayes, 1984). Seismicity is lower in the trench itself (5A) than in the forearc (5B). Present day volcanic activity in the forearc is an indication of convergence between the South China Sea Plate and Luzon (Hamburger et al., 1983). Convergence rate is estimated at about 10 to 20 mm per year (Hayes and Lewis, 1984).

Zone 6. Zone 6 comprises the Negros Trench and the Sulu Trench (6A) and their volcanic forearc (6B). Seismicity is relatively low in this subduction zone. There are relatively few shallow earthquakes of the thrust type in the Negros Trench. However, seismic refraction profiles show sediments being underthrusted to the east along the Negros Trench (Cardwell et al., 1980; Hamilton, 1979). There is no clearly defined Benioff zone; but there are intermediate earthquakes suggesting that the lithosphere is being subducted eastward (Cardwell et al., 1980). The Sulu Ridge (6B) parallels the Palawan Ridge which has no seismicity at all. The Sulu Ridge is associated with a subduction that occurred from the Late Cenozoic to Pleistocene (Cardwell et al., 1980). The Negros Trench and the Sulu Trench are considered to be one tectonic unit (Divis, 1980). Kanlaon is an active volcano on Negros island.

Zones 7 and 8. Zone 7 is a shallower structure, while Zone 8 is the deeper structure and is the northern extension of the Molucca Sea Plate. This plate had buckled and dips both westward and eastward. Its surface expression is the Sangihe Ridge. Zone 8 is the westward dipping portion of the Molucca Sea Plate. It is characterized by intermediate earthquakes (8B) and deep earthquakes (8A), as far as 680 km (Cardwell et al., 1980).

Fault Zones 9 to 18

Following the division of Philippine faults into transcurrent, normal and thrust faults according to the Philippine Bureau of Mines (1981), three transcurrent, two normal, and thrust faults are considered very probably seismically active. In addition, two transform faults are added. Thus, a total of ten faults are selected as source zones. In the contest of the methodology commonly in use, there are two possible ways of viewing faults. One is to regard them as line sources; the other is to treat them as finite-width sources. In regarding them as line sources, as for example in McGuire's 'Frisk' program (1978), additional fault parameters such as rupture length have to be considered. In treating them as finite-width sources, their parameters are no different from those of zones 1 to 8 earlier described. A test was made to compare the results of treating a fault as a line source and as a finite-width source. The results agree very closely. Thus, as a measure of convenience, faults are considered finite-width sources and included in the same computation used for Zones 1 to 8.

Zone 9. Zone 9 is the transcurrent Philippine Fault that extends over 1200 km from Lingayen Gulf in Luzon to Davao Gulf south of Mindanao (Allen, 1962). Krause (1966) suggests that it extends south of Mindanao along a submarine scarp into the Talaud Islands. Movement is left-lateral strike-slip (Ranneft et al., 1960; Allen, 1962; Rutland, 1968). Morante and Allen (1974) studied the geomorphic effects of the 1973 Regay Gulf earthquake and found a left-lateral displacement of 3.2 m near the Tayabas Isthmus of Southern Luzon. This was later confirmed by an earthquake focal mechanism solution of Lewis and Hayes (1983). Other earthquakes (1937, 1973, 1975) studied by Acharya and Aggarwal (1980) have focal mechanisms that can be correlated with the left-lateral movement along the fault. Geomorphic features in the other parts of Luzon, Masbate and Leyte likewise indicate left-lateral movements (Allen, 1962). Eight other large earthquakes, namely, of 1893, 1901, 1911, 1924, 1937, 1941, 1947, 1948, had their epicenters along or very near the fault zone (Rowlett and Kelleher, 1976). Thus seismicity gives evidence that the Philippine Fault is presently active, at least in some parts. Additional evidence from geology, such as the sharpness of fault scarps, disrupted soil horizons and stream offsets confirmed that the fault has been active since Quaternary time (Lewis and Hayes, 1983). Certain surface deformations near and along the fault have been associated with historical earthquakes such as those of 1989, 1879, and 1983 (Allen, 1962). In Central Luzon, the fault divides the mountainous Cordillera Central in the north from the lowlands of the Central Valley Basin in the south. Past episodes of intense activity along the fault have been placed in Late-Miocene and Post-pliocene (Rutland, 1968).

Zone 10. Zone 10 is another transcurrent fault, the Tablas Lineament that is treaceable for about 350 km from Western Panay northward through Tablas Island to the Tayabas Isthmus (Phil. Bureau of Mines, 1981). Allen (1962) pointed out it might be conjugate to the Philippine Fault and thus, right-lateral.

Zone 11. Zone 11 is the third transcurrent fault, called Mindanao Fault. It is traceable for about 400 km, from the Davao Gulf northwestward to the Sindangan Valley of the Northern Zamboanga (Phil. Bureau of Mines, 1981; Gervasio, 1964). On its northwest end there is a possibility it might be a high-angle thrust; but it is believed to be more probably a transcurrent fault. There is a fourth transcurrent fault, the Ulugan Fault in the Island of Palawan, but it is considered inactive because its seismicity is practically nil.

Zones 12 and 13. Zone 12 is a normal fault on the northeast side of Mindanao. Zone 13 is the Cotabato Normal Fault on the southwest flank of Mindanao. Another normal fault, the Marikina Fault, located east of Manila, is not included because it is considered inactive.

Zones 14 to 16. Zone 14 is the Zambales Thrust Fault on the western part of Luzon, that is north of Manila Bay. Zone 15 is a thrust fault on the southwest side of Mindoro. Zone 16 is a thrust fault on the western flank of Panay Island. The series of thrust faults along Zamboanga peninsula are not included here because they are considered to be inactive.

Zones 17 and 18. Zone 17 is a transform fault at about north latitude 15.5 degrees linking the East Luzon Trench (Zone 1) with the Philippine Trench (Zones 2 and 3) (Lewis and Hayes, 1983; Hamburger et al., 1983). Confirmatory evidence consists of concentrated seismicity, sharp bathymetric low, and focal mechanism solutions of two earthquakes (seno and Kurita, 1978; Cardwell et al., 1980). Zone 18 is a transform fault running along the Verde Island passage north of Mindoro. Supposedly it links the Manila Trench and the Negros Trench. This interpretation finds confirmation in the intense or concentrated seismicity north of Mindoro (Wolfe and Self, 1983). Its sense of movement is believed to be left-lateral (Lewis and hayes. 1984).

THE ROSSI-FOREL SCALE OF EARTHQUAKE INTENSITIES
(SEEASE, 1985)

I. Hardly perceptible shock - felt only by an experienced observer under favourable conditions.

II. Extremely feeble shock - felt by a small number of persons at rest.

III. Very feeble shock - felt by several persons at rest. Duration and direction may be perceptible. Sometimes dizziness or nausea expereinced.

IV. Feeble shock - felt generally indoors, outdoors by a few. Hanging objects swing slightly. Creaking of frames of houses.

V. Shock of moderate intensity - felt generally by everyone. Hanging objects swing freely. Overturning of all tall vases and unstable objects.

VI. Fairly strong shock - general awakening of those asleep. Some frightened persons leave their houses. Stopping of pendulum clocks. Oscillation of hanging lamps. Slight damage to very old or poorly-built structures.

VII. Strong shock - overturning of movable objects. General alarm, all run outdoors. Damage slight in well-built houses, considerable in old or poorly-built structures, old walls, etc. Some landslides from hills and steep banks. Cracks in road surfaces.

VIII. Very strong shock - people panicky. Trees shaken strongly. Changes in the flow of springs and wells. Sand and mud ejected from fissures in soft ground. Small landslides.

IX. Extremely strong shock - panic general. Partial or total destruction of some buildings. Fissures in ground. Landslides and rock falls.

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