ABSTRACTS OF PAPERS AT THE INTERNATIONAL SYMPOSIUM ON GEOLOGIC EVOLUTION, RESOURCES AND GEOLOGIC HAZARDS

The International Symposium was held in December 1982 under the heading of "Geologic Evolution, Resources and Geologic Hazards", as a part of the Institute for Transfer of Industrial Technology Programme of the Agency of Industrial Science and Technology. This was to commemorate the centennial of the Geological Survey of Japan.

Within this very ambitious framework, twenty-four internationally known scientists presented papers. Very stimulating ideas were put forward, active discussions were conducted and the importance of the role which geoscientists play for economic and social development was stressed.

The abstracts of the papers are presented in the following pages and the proceedings of the symposium containing the full papers will be published later by the Geological Survey of Japan.

GEOLOGICAL STRUCTURE AND EVOLUTION OF CONTINENTAL MARGINS

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Governments and industry have recently become intensely interested in exploring all available sedimentary basins whose hydrocarbon potential has not yet been assessed. This is primarily due to the rapid growth of world demand for energy caused by the increase in the world population. The most important prospective areas of the future are thought to be the continental margins, located seaward of the shelf areas under 200 m to 400 m of water.

The Federal Institute for Geosciences and Natural Resources has carried out geoscientific reconnaissance surveys on different continental margins with the objective of clarifying the geological structure and gological development of the continental margins and to develop criteria by which the hydrocarbon potential of these areas can be derived. Results of this research effort from convergent margins (Arafura Sea, South China Sea) and from divergent margins (Northwest Africa, Norwegian-Greenland Seas, Labrador Sea, Coral Sea, Weddell Sea/Antarctica) are presented. The most attractive research and exploration goals for the near future are, according to the results of the studies of BGR:

—Mesozoic horst and graben complexes that were formed during the initial opening phase of the oceanic basins;

—Carbonate platform edges and carbonate reef complexes;

—turbidite sand complexes and

—updomings beneath the seaward edge of accretionary wedges.

The phenomenon of buried "wedges of oceanward dipping sud-acoustic basement reflector" observed at a number of passive margins worldwide is also disussed.

GONDWANA GEOLOGY OF INDIAN PLATE: ITS HISTORY OF FRAGMENTATION AND DISPERSION

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The Gondwana rocks of India show a varied array of lithofacies spanning in age from Upper Carboniferous to Lower Cretaceous period and exhibit characteristic floral and faunal bondage with the homotaxial rocks of Southern Hemisphere. The fault bounded Gondwana troughs of Peninsular India are a mosaic of tilted blocks formed by major

normal faults and the basin belts show broad similarity in their structural setting with that of East African Rift, Baikal Rift and Rhine Graben. Based on geophysical data, a mechanism of convective upwelling of mantle material has been invoked for Gondwana graben formation.

In the Extra Peninsular India, the faunal zones and correlative lithofacies of Gondwanic affinity occur not only in the frontal zone of the Himalayas but also in the Tethyan domain of Kashmir, Spiti, Nepal and Sikkim. It is, however, suggested that Gondwanic India, with its lithological and palaeontological entity, extended northwards up to Indus-Tsangpo Suture and the Himalayan front in the Tethys-facing margin of Indian Gondwana Plate.

The spatial and temporal relation of the Rajmahal volcanism with that of the evolution of Late Gondwana east coastal troughs indicates that the initial phase of rifting and ocean floor spreading along the eastern margin commenced 100–105 million years ago and the ocean opening began with the continental rupture and uplift-generated triple junction formation. The fragmentation of western margin of Indian Gondwanic Plate was earlier considered to be a Late Cretaceous event but recent reappraisal of the age of Deccan volcanics, analysis of the evolutional history of Cambay graben in the west coast and the pattern of Cretaceous marine transgression during the deposition of Lameta and Bagh beds prove beyond doubt that the fragmentation along western margin of India and the beginning of ocean floor spreading took place in Lower Cretaceous period. In other words, both the eastern and western margins of Gondwanic Plate of India bear coeval records of fragmentation and continental dispersal.

THE LAST 200 MILLION YEARS IN EASTERN ASIA: YANSHANIAN SUBDUCTION AND POST-YANSHANIAN EXTENSION

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The pre-Yanshanian (pre-200 Ma) geology of Asia can be interpreted as an unique record of numerous small plates, some of which were separate rifted blocks as early as 1,500 Ma. The north-south agglomeration of these blocks to form the bulk of modern Asia began in the west during the Carboniferous (Hercynian events) and climaxed in the east during the Late Triassic (Indosinian events). In the eastern part of the continent, four major east-trending sutures (Red River, Qin Ling, Yan Shan, and Mongol-Okhotsk) bound three major blocks (respectively, South China, North China-Korea, and Manchuria-Bureya).

The Yanshanian geology in eastern Asia, particularly the widespread belts of calc-alkaline igneous rocks, can be interpreted as resulting from magmatism superposed above major peripheral subduction zones that dipped northwestward under South China and westward under North China-Korea and Central Mongolia from 200 to 100 Ma, and westward under North China-Korea (fronted by Southwest Honshu) and Manchuria-Bureya from 100 to 50 Ma. Some subduction also took place from 200 to 100 Ma, parallel to the Qin Ling, Yan Shan, and Mongol-Okhotsk sutures, as all finally closed. Hydrocarbon-rich basins formed as the result of major epeirogenic subsidence on western margins of the oldest continental nuclei farthest from the eastern subduction zones. Rates of subsidence and subduction appear correlative; areas of magmatic arcs and volumes of sedimentary basins reflects subduction rates; both reach a maximum in the Late Jurassic and Early Cretaceous.

The post-Yanshanian (since 50 Ma) geology in eastern Asia can be interpreted as resulting from northeast-southwest crustal extension in the region between the Siberian craton and the continental margin from Primorye to Taiwan, contemporaneously with collisions between Asia and the Okhotsk block in the northeast, the India block in the soutwest, and the Philippine arc in the southeast. The extension is evidenced by hydrocarbon-rich Tertiary graben, by voluminous Late Tertiary alkalic basalt volcanism localized along former plate sutures, and by historically recorded, scattered, intraplate, shallow seismicity.

TECTONIC EVOLUTION OF THE WESTERN PACIFIC REGION

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Marginal basins and subduction zones of early Tertiary age in the western Pacific region suggest

that there was another plate in addition to the Pacific and Australian plates in southwest Pacific during this period. This hypothesized plate was separated from Pacific by the mid-oceanic ridge system to the north and moving to the south, subducting beneath the Australian continental margin. The abrupt change of the Pacific plate motion at 43 Ma would have been caused by the annihilation of this plate beneath Australia by this time.

Since the middle Cretaceous (100 Ma) at least the western Pacific region has been the place of the interaction between the Asia or the Australia and the Pacific plates in the general plate tectonic scheme. Since the Pacific plate was moving north-northwestward untill 43 Ma and the Australia plate was in contrast stationary to hot spots from 70 Ma, the nature of the plate boundary between the Pacific and Australia was divergent (e.g., HILDE *et al.*, 1977).

However, the geological and geophysical evidence during early Tertiary does not support this. From the Philippine Sea to the northwestern margin of the Australian continental shelf, which were located more south at that time, there is an indication of subduction during the Paleocene to the middle Eocene. In the Philippine Sea, the northern half of the Palau-Kyushu Ridge was an active island arc since 48 Ma, when the Bonin arc was located juxtaposed with this ridge. The reconstruction of the Philippine Sea at 48 Ma shows that the trend of this arc was northwest and the west Philippine Basin was currently opening behind this arc. At this time, the Pacific plate was moving to the north-northwest with respect to hot spots, which makes for the Pacific plate difficult to subduct beneath the west Philippine Basin. In New Guinea, along the medial mountains, there is a suture zone where arc-continent collision occurred since the early Miocene. The northern half of New Guinea was a south-facing island arc which was active during late Cretaceous to early Miocene.

This implies that there was another plate different from Pacific and including northern New Guinea. The seafloor north of the Australian continental shelf had been subducting beneath this plate during Paleogene. Further to the east, there are the Coral Sea Basin and the south New Hebrides Basin, which opened during the Paleocene or early Eocene. There is no obvious associated island arc with these basins; however, it is plausible that they had opened related with subduction. Magnetic anomalies trend roughly in E-W direction in these basins. All these lines of evidence indicate that there was another plate in addition to Pacific during early Tertiary and this plate was subducting to the south beneath Australia. The Pacific plate had to be bounded by the ridge-transform fault system from this plate. The ridge subduction would have occurred in the lastest stage along the northern margin of Australia and resulted in the change of the nature of the southern plate boundary of the Pacific plate. This could cause the abrupt change of the Pacific plate motion from north-northwest to west-northwest because the ridge-push force would have diminished according to the ridge subduction.

GEOLOGICAL STRUCTURE AND EVOLUTION OF CONTINENTAL MARGIN AROUND JAPAN

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Several modern arcs are observed in the continental margin around Japan, in which some fundamental geomorphologic elements are distinguished. They are the trench, forearc basement high, volcanic chain and marginal basin. These geomorphologic features are variable both by the mode of development and their locations, which may be reflections of cummulative effects since subduction occurred.

Subduction complex in the trench is primarily governed by thrusts. Some of them have possibilities to cut the underthrusted oceanic basement beneath the complex, which may suggest that there may be no consumption of the subduction complex to deeper parts of the subduction zone beneath the continental crust.

A possible mechanism for arc volcanism is suggested as an alternative activity with marginal sea spreading and also a related activity to the subduction complex in the trench on the basis of convection current under the arc formed by the frictional heating along the boundary between subducted oceanic slab and asthenosphere under the arc.

A few stages for development are suggested in arcs, which may suggest temporal variations of fundamental framework of arcs.

It is inferred from the facts that forearc and backarc features may be joined as a related pheno-

menon to constitute arc.

GEOLOGY AND GEOTHERMAL RESOURCES IN NORTHERN THAILAND

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The stratigraphic succession in northern Thailand is summarized from Precambrian to Quaternary including the important igneous activities. In addition, the significances of heat sources, fault structures, origin of thermal water and the general surface discharge features which are related to the geothermal resources are also discussed.

The Precambrian rocks are mainly composed of gneisses whose age is inferred from their metamorphic grade and more complex intrusives history, compared with the adjacent low grade or unmetamorphosed Lower Paleozoic rocks. Arenaceous and calcareous rocks intercalated with some volcanics are recognized to be the Upper Paleozoic sequence.

The Lower Mesozoic rocks are characterized by volcanic rocks and marine sediments whereas the Middle Mesozoic sequence is composed predominatly of continental sediments.

The Tertiary and Quaternary sediments basically predominate a large number of basins over the region.

The geothermal fields in Thailand are believed to be associated with igneous activities of possibly Cretaceous to Tertiary ages. Presumably, the probable heat source is contributed from tectonic movements and/or radioactive elements from some granitic batholiths.

The average temperature of thermal waters ranges from 60 —100°C with some warm springs of 45–60°C and they are classified as sodium-bicarbonate type. Most of the thermal water in northern Thailand are originated from local meteoric water and probably diluted from cold ground water at shallow depth.

GEOTHERMAL EXPLORATION OF EBURRU AREA, KENYA

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Eburru area is situated about 120 km NW of Nairobi whithin the mid-Rift Valley region. The Eburru geothermal prospect was one of the three geothermal prospects identified by the UNDP geothermal exploration project between 1970 and 1978, the other two being Olkaria and Bogoria. Eburru and Olkaria prospects are about 20 km apart and close to the shores of fresh-water lake of Naivasha.

The geothermal surface exploration of Eburru prospect was started three years ago by a joint team of Japan International Cooperation Ageney (JICA) experts and Ministry of Energy (MOE) staff. The team has updated the mapping of the Tertiary/Quaternary volcanics, mapped and sampled the alteration zones and undertaken both geochemical and geophysical survey of the prospect.

The results of the exploration work indicate the existence of a N-S fault zone within which are recent volcanics and phreatic craters. At the top of Eburru Hill are major steam emanations and alteration zones closely related to carbon dioxide and mercury geochemical (in soil air and soil) anomalies as well as resistivity anomalites. The alteration zones and geochemical and geophysical anomalies have been observed in the N-S fault zone up to, and beyond, old Eburru railway station. The results indicate good steam conditions at the top of Eburru Hill and hot water conditions at the base of the hill (about 600 m below) near Eburru station. Shallow drilling is proposed in 1983 followed by deep drilling work. There is a need to extend the geothermal surface exploration area to the north and south. Meanwhile two 15 MW power stations are in operation at Olkaria Geothermal field. The average depth of the steam wells is 1000 m.

PHILIPPINE GEOTHERMAL RESOURCES: AN ALTERNATIVE INDIGENOUS ENERGY

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The Philippines is indeed fortunate to be located within the West Pacific Island Arc dotted by Neogene volcanic centers. The multi-stage development of volcanic and plutonic events in this western part of the Circum-Pacific basin have generated regions of high heat flow where known potential geothermal

resources are located.

With the increasing power demands, reflecting a favorable growth of the country's economy, the Philippine government has embarked on an accelerated program to harness the country's geothermal energy for power utilization immediately following the start of the energy crisis in the early 70's.

For a period of ten years (1973–1982), the Philippines has successfully maintained a systematic and continuing program of assessing, exploring, developing and exploiting its vast potential geothermal resources. Of the several potential areas scattered all over the archipelago, four geothermal fields have already contributed some 556 megawatts to the total electrical power generation.

This paper deals with the geothermal resource development in the Philippines, a major achievement of a developing country of the Third World in regard to the utilization of new and renewable sources of energy.

GEOTHERMAL EXPLORATION IN JAPAN

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Japanese energy consumption has been constantly growing with the development of industry and the advance of living level of the people. Based on this energy situation, the Japanese government started the program to accelerate the development of alternative energy about ten years ago. Geothermal energy is considered to be the most realistic alternative energy available with present technology and under current economic situation. According to the Japanese long term energy policy, it is expected that, in 1995, the total installed capacity of geothermal power plants will increase to 3,000 MW, although present capacity is only 215 MW.

To attain this difficult target, the Japanese government started various geothermal projects including exploration. The exploration can be classified into two major categories, that is, 1) assessment of the nation's geothermal resources and 2) development of deep (2500–3000 m) geothermal reservoirs.

This paper deals with the exploration activities by the government, especially "Nation-Wide Survey for Geothermal Resources" and "Hohi Project", both of which are presently underway.

NON-MARINE PETROLEUM GEOLOGY OF CHINA

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Taking a comprehensive view of the geological history of China, it appears that the formation of the petroliferous basins occurred in two periods. Firstly, the period of developing marine basins mainly on platforms from the end of early Proterozoic to the end of Paleozoic; and secondly, the period of developing non-marine petroliferous basins during Meso-Cenozoic. The Chinese petroleum geologists have been focussing their effort on the Meso-Cenozoic non-marine basins for many years. As geological data have been increasingly acquired, it is possible to propose a new theory as follows: a large amount of hydrocarbons can be generated and accumulated to form major oil and gas fields in the non-marine basins.

The study on non-marine facies has revealed that there is no fundamental difference between the non-marine and the marine strata in respect to the mechanism of oil generation. Naturally, when comparing oil-bearing strata of the non-marine and marine facies, there are some differences between the two facies regarding the depositional environment, the nature of their organic matter etc.

As regards the reservoir rocks, the research on beach and deltaic facies closely related to the formation of major oil and gas fields has reaped rich fruits one after another, and turbidites are also found.

The Meso-Cenozoic petroliferous basins of China can be divided into the following three types:

a) The first type of basins pertains to folded zones and is controlled by orogeny in both the formation and the development.

b) The second type of basins pertains to platforms, controlled by epeirogeny in both the formation and the development.

c) The third type of basins those lying on complicated basement structures and formed under the effect of Alpine movement.

PETROLEUM GEOLOGICAL FEATURES AND TECHNICAL PROBLEMS IN HYDROCARBON EXPLORATION IN JAPAN AS AN ISLAND ARC

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The geology of the Japanese islands is complicated because of several island arcs meet there. The geological features of those island arcs essentially resemble each other, but in detail, they show various differences. Indeed, economic oil and/or gas production has been done only from the inner arc of the Northeast Japan Arc, except for a very small production from the central zone of Hokkaido and the outer arc of the Southwest Japan Arc. Recently, a gas field was discovered at the outer arc of the Northeast Japan Arc, which will be developed soon.

The basin of the inner arc of the Northeast Japan Arc, which is the most productive, began to develop at the Oligocene and has grown where the Asian continent was cracked along its margin by the tensional stress resulting from the subduction of the Pacific plate. The basin is characterized by strong volcanism and differential movement of the small blocks within the basin. From the view point of petroleum geology, these characteristics cause the following features: 1) distinct horizontal changes in thickness and lithology of the sediments, 2) discontinuity of the reservoirs, 3) development of volcanic or tuffaceous sand reservoirs, 4) complicated and steep traps, 5) abundance of highly pressured and caving formations, 6) relatively high geothermal gradient, and so on. These features bring about various technical problems in hydrocarbon exploration.

DEEP SEA BASINS IN INDONESIA

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Recent offshore sedimentary basins in Indonesia, located in water depths below 200 m, are discussed on the basin of their tectonic origin and evolution. They are described in terms of their shape, their sedimentary fill and petroleum potential.

Some of the basins discussed have sedimentary thickness up to 5 seconds two way seismic time. In cases where basins are underlain by continental crust the sedimentary column can be considerably thicker if the sedimentary rocks of the underlying continent are added. Basins are delineated by the 1.0 second thickness isopach which is considered the minimum sedimentary thickness for hydrocarbon prospect.

Forty-one basins fulfill the definition of having a sedimentary fill of more than 1 second of seismic data (TWT). These basins cover an area 1,252,250 km^2 and occupy 55% of the total area of all basins in Indonesia.

The basins can be situated either marginal to emerged land or isolated from it. In the first type, basins are narrow, parallel to the emerged land, often bounded by faults and are filled with clastic erosional products. Shales are dominant but fill also includes coarser clastics. Deltaic and littoral clastics are subordinate while turbidites predominate. Carbonates are developed occasionally on basement highs or near shore. The second type of basin is often located in deep water. Recent sediments are only deposited as veneer.

Structural deformations, which are visible on many seismic sections show a larger amplitude at depth as compared to those in the Recent deposits. A large variety of possible traps including compressional folds, dragfolds, block faulting and also shale diapirism, draping-over-highs and reef-buildups are exhibited in recent sedimentary basins throughout Indonesia.

CHARACTERISTICS OF COAL IN CONTINENTAL AND ISLAND ARC ENVIRONMENT

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Interpretation of the petrographic results assists preliminary geological and economical evaluation of coal deposits. An attempt is made to determine the coal-forming environment by utilization of petrological analyses and to make comparison of petrographic analyses with ultimate and proximate analyses throughout the island arc region including

Japan, Indonesia and Philippines and the continental region including USA, Canada and Australia.

As a result, upper Permian Australian coal was formed under dry conditions or lower water table, and characterized by lower calorific value, volatile matter content and H/C atomic ratio. On the other hand, Pennsylvanian American and Canadian coals were formed under comparatively dry conditions, and characterized by medium calorific value, volatile matter content and H/C atomic ratio.

Tertiary coals of Australia were formed under slightly more wet conditions compared to the upper Permian ones, and shows nearly the same coal properties as the Pennsylvanian North American coal type within the same coal rank. But Paleogene coals of North America were formed under drier condtions than the Pennsylvanian coal and show nearly the same coal properties as the Pennsylvanian North American coal type within the same coal rank.

On the contrary, Tertiary coals of the island arc regions are quite different from the coals of both Australia and North America, and were formed under wet conditions or higher water table, characterized by higher calorific value, volatile matter content and H/C atomic ratio.

METALLOGENY OF EAST ASIA: Sn, W AND Mo PROBLEMS

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Characteristic of this region is the strong concentration of tungsten deposits which were formed in Jurassic in southern China and late Cretaceous in southern Korea and Japan. Tungsten is often associated with tin or molybdenum, and tin and molybdenum are generally incompatible in a single ore deposit or in a given province. In Japan, Sn/W ratio decreases and Mo/W ratio increases with time from 95 Ma onward, but this time dependance is unclear in southern Korea and may not be existed in southern China.

In southern China, tungsten and molybdenum provinces are clearly separated in the south and north. Tungsten and minor tin are concentrated as vein and skarn in the Nanling Range and its vicinity, while molybdenum occurs in skarn and vein from the Qin Ling suture northward. In Japan, tungsten and molybdenum provinces are also clearly separated across the island arc.

There are many lines of evidence that the ul-

Metallogeny of East Asia includes the following commodities

AGE		E. CHINA (GUO *et al.*, 1982)	S. KOREA (PARK, 1981)	JAPAN (ISHIHARA, 1978)
CENOZOIC	LATE	—	—	S, Kuroko: Au-Ag, Cu-Pb-Zn, Mn vein (MT) Sn, W, Hg skarn and vein (IL)
	EARLY	Porphyry Cu, Au, Mo	Fe, Cu, W vein, brec. pipe (MT)	Mo, Pb-Zn skarn and vein (MT)
MESOZOIC	LATE	Fe-Cu skarn, porphyry Pb-Zn, Au skarn, vein (MT)	W, Mo, Cu, Pb-Zn skarn and vein (MT)	Cu-Fe skarn, (Kuroko) W (scheelite)-Au vein, pipe (MT)
	MID-EARLY	W, Sn, RE, Hg, Sb vein and skarn (IL) Porphyry Cu-Mo, W (MT)	Mo-W vein and skarn (MT or IL) Au vein (IL?)	Some basalt hosted Cu-FeS_2
PALEO-ZOIC	LATE	V-Ti-Fe, Cu-Ni-, Cr etc (mafic rx) Minor porphyry Cu-Mo, Fe-Cu-Pb-Zn skarn		Basalt hosted Cu-FeS_2 (Besshi type)
	EARLY	Basalt hosted(?) Cu-FeS_2 Cu-Ni (mafic rocks)	Sedimentary U, V Hematite (BIF?)	—
PROTEROZOIC		Stratabound Cu, Pb-Zn	Graphite, hematite (BIF?)	—
ARCHEAN		BIF, Algoma type	—	—

(IL): Ore deposits that occur in the ilmenite-series granitic terrain,
(MT): Those occurring in the magnetite-series granitic terrain.

timate source of tungsten and tin is cratonic. Concentration prosesses in magmatic stage appear to be also essential to form ore-grade concentrations of these metals. The tungsten and tin deposits were formed by magmatic fractionation of a reduced, ilmenite-series magmas originated in Precambrian basement rich in lithophile components, whereas molybdenum deposits were formed by that of an oxidized, magnetite-series magmas derived from the lower continental crust.

Tungsten and molybdenum distribution in southern Korea has been a puzzling problem, where these elements are not separated regionally as well as in a single ore deposit. The tungsten-molybdenum deposits appear to be associated with granitic magmas that are intermediate in terms of oxygen fugacity.

Another characteristic mineralization in the Mesozoic East Asia is the Yangtze River type copper-magnetite deposits. This is related to highly oxidized-type mafic magmas which have a deep origin and seem initially oxidized. Cause for this oxidation remains unsolved.

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GEOLOGY AND TECTONIC SETTING OF COPPER AND CHROMITE DEPOSITS OF THE PHILIPPINES

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The Philippines is an amalgamation of various crustal terranes (magmatic arcs, ophiolites, microcontinents) that have coalesced in response to complex and rapidly changing interaction, since the Mesozoic, between converging megaplates. Several sets of collided magmatic arcs and trench sutures have been proposed to interpret its metallogenesis, on the basis of structural ridges and basins which define the archipelago.

Copper deposits in the Philippines are genetically classified into those of oceanic and island arc origins. The first includes the Cyprus-type massive sulfides and the vein-type deposits exclusively found in thrusted/uplifted ultramafic rocks in ophiolitic terranes. Metamorphosed equivalents of these deposits are the Besshi-type, associated with basic schists.

Island arc copper deposits are the Kuroko, pophyry copper, contact metasomatic and vein-type deposits whose origins are generally related to thermo-chemical processes associated with calc-alkaline magmatism, stress regimes in the upper crust and possible anomalous enrichment of metals related to the rate and/or stage of subduction.

Chromite deposits in the Philippines are of podiform type and exclusively found in ophiolitic terranes where metamorphic harzburgite immediately below gabbro is exposed. The most prospective horizon is within 1.4 km below the gabbro-peridotite transition, with the largest and most frequent occurrence close to 1.0 km -level.

Differentiation of the distribution and ages of mineralization of these deposit-type, on the basis of the evolution of their associated magmatic and ophiolitic terranes, could serve as important guides in the exploration of similar deposits.

TIN DEPOSITS IN MALAYSIA AND THEIR SIGNIFICANCE TO THE REGION

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West Malaysia can be divided into three different metallogenic belts each with intrusions of granitoids, i.e. the Main Range Batholith, the Central Region and the East Coast Region. The granitoids of the Main Range Batholith and the East coast Region contain most of the economic tin deposits, whereas cassiterite concentrations in the Central Region are insufficient for economic exploitation.

Rb: Sr whole rock studies of the granitoids indicate intrusions in the Late Devonian (360 Ma), Late Carboniferous-Triassic (200 Ma), Late Cretaceous (85 Ma). K: Ar datings indicate that epioro-

genic heating events occurred in the Upper Jurassic/Cretaceous boundary, and also in the Late Cretaceous. WNW wrench faulting also occurred in 33 Ma.

Sr^{87}/Sr^{86} studies suggested that the acid intrusives are not derived from the mantle but originated from the sial or the product of assimilation of sialic material with a basic magma.

Rb: Sr ratios indicate that the Main Range instusives are more differentiated compared to the East Coast granitoids.

Tin mineralization is thought to be genetically related to the tin bearing granitoids but there are also tin barren areas even though the same batholith crops out in these areas.

The tin deposits can be classified into pegmatitic, stockworks, pipes, fracture fillings, pyrometasomatic replacements, lode tin, tin-iron deposits, hydrothermal veins swarms, alluvial and eluvial, and aplite deposits.

Tin mineralization is not confined to any specific geochronological event nor is hornblende granite that is barren for tin. The difference in mineralization in the three metallogenic belts and the paucity of tin deposits in tin bearing granites are explained.

Malaysian granitoids are thought to be multiphased intrusives having undergone intra-intrusive processes. Tin is derived from the intrusive itself or introduced later.

Tin had been the pillar of Malaysian economy, but its contribution to the GDP is slowly dwindling. Reserves are gradually and surely being depleted. The threat to tin by substitutes is a constant battle. Recent world recession and the huge stockpile held by the US and the International Tin Council has depressed the price of tin which if not arrested will be a severe blow to the tin industry in Malaysia.

TUNGSTEN AND MOLYBDENUM ORE DEPOSITS IN SOUTH KOREA

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South Korea has been one of the largest tungsten producing countries in the Western World. Her tungsten supply to the Western World is as much as 10%.

South Korea has more than 500 tungsten and molybdenum claims within the country with the main concentration at the northeast provinces of South Korea. Among these, 34 mines have been developed for tungsten and/or molybdenum.

The generally accepted South Korean metallogenic epochs are fourfold: Precambrian, Paleozoic, Jurassic to early Cretaceous, and late Cretaceous to Early Tertiary. The tungsten and molybdenum were mineralized during the last two metallogenic epochs with close relationship to the Daebo granite and Bulkuksa granite magmatism.

The Korean tungsten and molybdenum deposits are classified into three main genetic groups: Pegmatite deposits, contact metasomatic deposits and hydrothermal deposits.

The hydrothermal deposit is further subdivided into three subtypes: vein type, breccia pipe type, and disseminated and stockwork type. The characteristics of these genetic groups and subtypes are generalized by comparing the ore mineral paragenesis and derscribed in detail by selecting one representative mine from each type: Ssangjeon mine for pegmatite type deposits, Sangdone scheelite mine for contact metasomatic deposits, Cheongyang mine for hydrothermal vein type deposits, Ilkwang mine for hydrothermal breccia pipe type deposits, and Sobo molybdenite mine for hydrothermal disseminated and stockwork deposits.

The homogenization temperatures of the fuid inclusions of the tungsten and molybdenum ore vein materials range from 200° to 500°C although its mineralization temperature is not conclusive.

Some of the mineralization ages measured from the vein materials of the tungsten and molybdenum ore bodies indicate late Cretaceous to early Tertiary which is similar to the Bulkuksa granite ages. Some other tungsten and molybdenum mineralizations are correlated to the Daebo granite from the field geologic evidence.

GEOLOGY OF CARBONATITES IN BRAZIL AND THEIR ECONOMIC MINERAL DEPOSITS

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Alkaline Complexes are recorded in many parts of Brazil and their intrucion occurred in Precambrian, Mesozoic and Cenozoic times.

The oldest ones appear in Bahia, Goiás, Pará, Amazonas and Mato Grosso States. The Cenozoic Complexes occur mainly in Ceará State and in the Fernando de Noronha and Trindade Islands.

The Mesozoic intrusions are by far the most important of the Brazillian Alkalic Complexes in terms of rock varieties and economic deposits. They occur mainly in the southern portion of the country and generally can be classified into two classes; those with carbonatites and those apparently without carbonatites. Dunites, peridotites, pyroxenites, serpentinites, gabbros and/or syenties are the main rocks of both classes, but the principal mineralizations in the latter are lateritic nickel and uranium, while the former has phosphate, niobium, titanium, rare-earths, vermiculite as the most important economic deposits.

At least fifteen carbonatite occurrences are recorded in Brazil, from which only one is in the Amazonian Region. Some of them contain important deposits of phosphate (Anitápolis, Lages in Santa Catarina State; Morro do Serrote and Jacupiranga in São Paulo State; Tapira, Serra Negra, Salitre in Minas Gerais State; Catalão in Goiás State), niobium and rare-earths (Araxá, Salitre, Catalão), titanium (Tapira, Araxá, Catalão) and vermiculite (Catalão). Uranium-thorium mineralizations are also found mainly in the Minas Gerais Complexes. The Araxá Complex is the main niobium orebody, with reserves of about 463 million tons of ore containing 2.5% Nb_2O_5. In Catalão, the rare-earths reserves are estimated to be 15 million tons of ore containing 4% $CeO_2 + La_2O_3$.

LANDSUBSIDENCE, INDUCED BY MAN AND THE COASTAL DEFENCE OF LOW-LYING AREAS, THE NETHERLANDS AS AN EXAMPLE

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The subsoil of the Netherlands consists of deposits, mainly supplied by the rivers Rhine and Meuse, filling the subsiding North Sea Basin. Interglacial sealevel rises in the past as well as during the Holocene, have led to incursions by the sea with subsequent erosion.

Man occupied and exploited the area. Peat digging and empoldering reinforced the natural process of tectonic subsidence. Empoldering leads to oxydation of peat and compaction of the subsoil. Groundwater withdrawal and hydrocarbon exploitation form more recent causes for further lowering of of the landsurface.

Recent sealevel studies confirm the idea, that the transgressive movement shows fluctuations in intensity. The studies demonstrated too, that during several periods, covering some centuries each, higher water levels have been recorded in the coastal areas as a result of storm surges and high discharge by the rivers. For these reasons coastal defence structures have to be of ever increasing size to prevent the land from flooding. It is perhaps an impossible task in the longrun, because of the sealevel rise. At the moment, coastal erosion seems to be related more to man's interference with natural processes.

THE SIGNIFICANCE OF EXPLOSIVE VOLCANISM IN THE PREHISTORY OF JAPAN

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As studies advanced in the description of specific features of tephra, a number of large-volume tephra layers spread over extensive areas in and around Japan were disclosed. Present paper is largely focused on the two large eruptions in Kyushu, the *Aira-Tn* eruption (ca. 21,000 BP) and the *Kikai-Akahoya* eruption (ca. 6,300 BP), and on their possible impacts on the prehistoric world.

The eruptions represented by the *Aira-Tn* and *Kikai-Akahoya* ashes are of ultra-plinian and/or phreato-plinian type, characterized by the explosive emission of at least tens of cubic kilometers of rhyolitic magmas resulting in-tephra-falls as well as pyroclastic flows of great magnitude. These big eruptions should have been responsible for forming the Aira and Kikai calderas as they are today with a diameter of 20 km. Large-scale pyroclastic flow deposits are distributed around the calderas forming extensive pyroclastic plateau. Fine-grained vitric ashes, the *Aira-Tn* and *Kikai-Akahoya*, which are confirmed to be as airfall part of pyroclastic flows, cover most of the Japanese islands as well as the floor of the northwest Pacific and the Japan Sea, forming important time-markers in the upper Quaternary sequences.

These violent tephragenic eruptions should have certain features and impacts, regardless of the specific environments in which they occur. The *Aira-Tn* ashfall would have given heavy impacts on the Japanese paleolithic world and the *Kikai-Akahoya* on the neolithic Jomon culture. Some archeological evidences suggest that South Kyushu was abandoned temporarily after the *Kikai-Akahoya* event and was re-occupied several hundred years ago by bearers of different cultural tradition.

VOLCANOES AND VOLCANIC HAZARDS IN PAPUA NEW GUINEA

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Papua New Guinea has fourteen active and 22 dormant volcanoes which are a danger to the lives of 204,000 people living in a total area of 16,000 square kilometres-that is 6.8% of the total population over 3.8% of the total land area of the country.

This paper describes the distribution of all the active and dormant volcanoes and details are given of their geographic locations, the sizes of the hazardous areas surrounding them and the numbers of people living within these.

A historical summary showing the frequency of recorded eruptions from the active volcanoes is presented, the erupion types are described, the percentages of active volcanoes showing the different eruption types have been calculated and a tabulated synopsis of the recorded hazardous eruptions of the volcanoes that have caused destruction and death and/or required avacuation has been drawn up.

The hazards presented by all the active and dormant volcanoes are considered and danger scores based on factors which reflect the likelihood of dangerous volcanic activity have been calculated and used together with the size of the population thought to be at risk in each case to produce a hazard rating for each volcanoe. The hazard ratings for the active and dormant volcanoes have then been listed in descending order of hazard rating to indicate which are the most potentially dangerous and which therefore most urgently require surveillance.

EXCAVATION SURVEY OF ACTIVE FAULTS FOR EARTHQUAKE PREDICTION IN JAPAN

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Geological Survey of Japan

The trench excavation survey plays a very important role in revealing the history of detailed movement of active faults in Japan. The trench survey in Japan began in the late 1970's stimulated by several excellent studies in the United States. The Geological Survey of Japan (GSJ) started a new comprehensive study of active faults from 1979 as a a part of the 4th Five-Year Program of the Japanese Earthquake Prediction Project and conducted the trench survey as one of its major activities.

GSJ excavated the Ukihashi central fault in 1980 and the Atera fault system in 1981. The Ukihashi central fault is one of the southern portion of the Tanna fault system which caused the Kita-Izu earthquake of 1930 (M. 7.0). It is inferred from the excavation that the reccurrence interval of the Ukihashi central fault is 3,000–4,000 years. The Atera fault is one of the most active faults in central Japan with NE-SW strike and 80 km length, which shows left lateral slip with northeastern upheaval component. From the excavation survey the Atera fault is estimated to have repeated the movements of 2,000–3,000 years reccurrence interval since 12,000 y.B.P. Judging from its long reccurrence interval and high long-term slip rate, it is suggested that the Atera fault has a high potential of causing a great earthquake with the displacement of 6–15 m. We have plans to excavate other active faults so that it will enable us to acquire many useful information for Earthquake Prediction.

THE IMPORTANCE OF AN INTERNATIONAL EARTHQUAKE DATA BANK

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Three strategies for minimizing earthquake hazards are: (1) avoid building in high seismic risk areas, (2) build structures that can withstand the effects of earthquakes, and (3) plan for earthquake emergencies, especially to predict earthquakes well in advance to minimize damages. In all these cases,

we need accurate data concerning earthquakes. This can be accomplished by systematically consolidating old data and collecting new data.

The idea of creating a global seismic data bank has been studied by a group of LASPEI/UNESCO experts. V. KARNIK completed the feasibility study, but so far funding for this multi-million dollar project has not been found. In this paper I will report my analysis of the data consolidation problem, and efforts towards organizing an international earthquake data bank. Such a bank should include every level of earthquake data, from seismograms to published papers. Implementation of this bank is technically feasible and can be done in one to two decades.

Five years ago, J. LANDER, H. MEYERS, I. NERSESOV and I started the Historical Seismogram Filming Project. We have copied about 400,000 seismograms on microfilm, about 20% of the significant seismograms. The bulk of seismograph station bulletins, which account for about half of all the earthquake literature, has also been microfilmed. In a related effort, the Current Earthquake Literature database contains over 10,000 papers from the last 5 years, and a computer-based archiving and retrieval system for earthquake data has been developed. When sufficient data are accessible, an accurate global earthquake catalog of the past 100 years can be rapidly produced. Such a catalog and the source materials in the data bank will provide valuable information to make better decisions and to aid research on earthquake hazards reduction.