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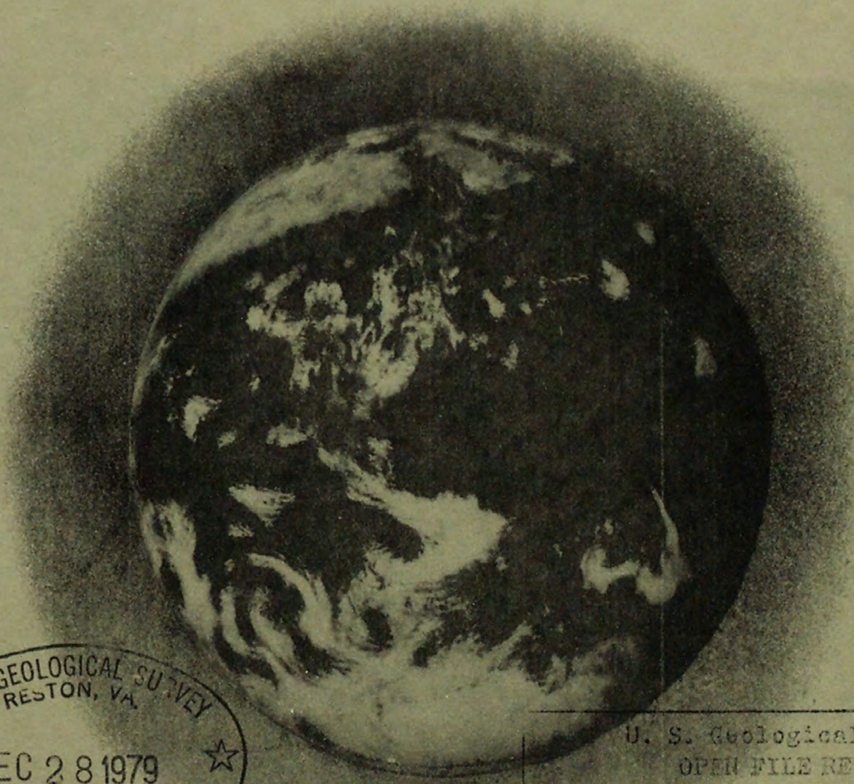
Addenda added 2/80

STATUS OF THE CIRCUM-PACIFIC MAP PROJECT

A Summary of the
Circum-Pacific Map Project Meeting
In Menlo Park, California
May 2-4, 1979



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1979

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Circum-Pacific Map Project Meeting

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May 2-4, 1979

By

Paul W. Richards
U.S. Geological Survey

The project report series presents information resulting from various kind of scientific, technical, or administrative studies. Reports may be preliminary in scope, provide interim results in advance of publication, or may be final documents.

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ATTACHMENTS

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INTRODUCTION

Panel Chairmen, contributors, and advisors to the Circum-Pacific Map Project met for their fourth annual project review at the U.S. Geological Survey (USGS) regional center, Menlo Park, California, May 2-4, 1979. The sessions were chaired by John A. Reinemund, Map Project General Chairman, with the assistance of Paul Richards and Project Advisors. Campbell Craddock, University of Wisconsin, attended for the first time as Chairman of the Antarctic Panel, replacing F. A. (Al) Wade who died in October, 1978. Dr. Tamotsu Nozawa of the Geological Survey of Japan attended, replacing Dr. Shun-ichi Sano, who has been transferred to Indonesia. H. Fred Doutch, Bureau of Mineral Resources, Canberra, was present for the first time and represented Australia's interests in the Project.

Joseph I. Ziony, Regional Geologist, Western Region, welcomed the group (attach. 1) and summarized USGS activities in the Western States. Michel T. Halbouty, Chairman of the Circum-Pacific Council on Energy and Mineral Resources, expressed, during the second day's session, the Council's appreciation for the accomplishments to date.

The following report summarizes the results of the 3-day meeting and presents updated, generally slightly revised, guidelines for the several map series that are being compiled.

TECTONICS AND MINERAL DEPOSITS

At the meeting, emphasis was placed on the relation of tectonics to mineral deposits, because the project is shifting from compilation of geologic maps to compilation of tectonic maps, and because several geologists active in these areas were available to describe their work. Chikao Nishiwaki discussed tectonic control of mineral distribution, relating porphyry copper deposits to Benioff zones. Discussions by members of the USGS in Menlo Park were as follows: J. P. Albers, metallogeny and tectonic terranes in California; D. L. Jones, tectonic terranes (allochthonous blocks) along the Pacific coast, mainly Alaska; R. G. Coleman, some results of the International Ophiolite Symposium in Nicosia, Cyprus, April 1979 (see attach. 2); W. P. Irwin, a review of the ophiolite map of California-Oregon region compiled for the International Geological Correlations Program (IGCP) Ophiolite Project; and P. C. Bateman, an update of the work of the IGCP Circum-Pacific Plutonism Project No. 30.

PROJECT-RELATED ACTIVITIES

Herbert Meyers of the National Geophysical and Solar-Terrestrial Data Center, (World Data Center A, WDC-A), Boulder, Colorado, reported on current data compilations of the Data Center (summarized in attach. 3 and 4). Recent map publications include: 1) "Geothermal Energy in the Western United States," which shows hydrothermal convection systems, igneous systems, low-temperature geothermal waters, and regional heatflow at a scale of 1:2,500,000. Maps of individual states, not yet published, also will show faults. 2) "Volcanoes of the World," which is compiled on a Mercator projection at a scale of approximately 1:60,000,000. The map shows Holocene volcanoes, classified according to frequency and dates of eruption, and is based on data compiled by Tom Simkin of the Smithsonian Institution.

Ed Davin, National Science Foundation (NSF), was unable to attend, but reported that maps and reports on the NSF-supported Nazca Plate Project will be published by the Geological Society of America within one year. These will include 10 maps in the GSA Map and Chart Series, and 18 papers in one volume.

CIRCUM-PACIFIC MAPS

Geographic and base maps

The geographic and base map series covering the Antarctic and quadrants of the Pacific region (see attach. 5) have been published by the American Association of Petroleum Geologists (AAPG). Michel Halbouty reported that as of April 1, 1979, of the 36,000 printed maps, a total of 2,021 had been sold. They brought a return of $29,295 on the $46,990 cost of printing. He reminded the group that using and displaying the maps will broaden their impact, as well as help AAPG recover their costs.

The maps are not without errors, many, if not all, of which can be corrected before the maps are used as bases for the future publications.

Some corrections were made for the Pacific Basin Map at scale 1:20,000,000 million. Other errors noted should be brought to the attention of John Reinemund.

Plate-tectonic maps

The plate-tectonic series, which is discussed first because it will be ready to publish first, will include seismic epicenters, Holocene volcanoes, and active lithospheric plates (attach. 6). The maps are planned for early publication to make the epicenter data available while they are timely, and to present an early product of the Project's activity. This map series will be of interest to a diverse group of map users. Compilation is proceeding as follows:

Epicenters.--The epicenters have been plotted for the 1:10 million-scale maps by the WDC-A; the Pacific Basin (1:20 million scale) map is still to be plotted. Epicenters for each depth interval (seven depths for the quadrant maps and three for the Pacific Basin map) are to be printed in a different color.

Holocene volcanoes.--The locations of Holocene volcanoes were computer-plotted by WDC-A and the USGS, and symbols have been placed over the plotted points. A change has been made since the May 1979 Menlo Park discussion: Two groups of historically active volcanoes, a group that was active during the years 1964-1977 and a second group active historically, but prior to 1964, will be shown as a single group of historically active volcanoes.

Lithospheric plates.--Each panel, except that for the Southeast quadrant, will compile an overlay showing active plates for its own area. This overlay will show, in one color, fracture zones, subduction zones, undisturbed oceanic crust, plate-related faults, and plate-motion vectors. Magnetic lineations and oceanic crustal age maps, compiled for the project by W. C. Pitman III, R. L. Larson, and X. Tchernitchin of Lamont-Doherty Geologic Observatory (LDGO), provide control for much of the overlay. Ms. Tchernitchin, in describing the maps, noted that most of the new data used in the compilations is for marginal sea basins.

K. J. Drummond, Mobil Oil Co., has compiled the plate-tectonic map for the Northeast Quadrant, and copies have been sent to the other Panel Chairmen for review. He has also volunteered to combine the maps of the four quadrants and Antarctica on the single map (1:20 million scale) for the Pacific Basin.

Two questions raised during the May meeting were not settled: Should plate boundaries be emphasized by a distinctive line or pattern, or should we let the oceanic crust pattern, faults, and subduction zones convey the sense of plate boundaries? Names of the plates will be shown on the maps. Should the term "plate" appear in the title? What should the final titles be?

The "plate" overlay compilations are to be sent to Reston, after reviews, so that they can be combined with epicenter and volcano data, and sent to the printer late in 1979. No maps will be sent to the printer until the others can follow in quick succession. The Northwest Quadrant map is to be ready for review during the meeting of the Committee for Coordination of Joint Prospecting for Mineral Resources in Asian Offshore Areas (CCOP) in September 1979, and the Southwest Quadrant map is to be compiled by that time also.

Geologic maps

Reviews by Panel Chairmen indicated that compilation of the land geology is substantially completed, although some revisions, particularly in Antarctica, must be made. Jose Corvalan has incorporated revisions for some South American countries on the Southeast Quadrant map; it is being reproduced in Reston to provide review copies.

Mapping of the seafloor geology has lagged. In 1976, Jane Frazer of Scripps Institution of Oceanography (SIO) provided a computer plot from the SIO data bank showing the lithology of the surficial sediments (attach. 7) at their sample sites. As Ms. Frazer pointed out at that time, however, those data represent the sample descriptions of numerous investigators. There was, therefore, no systematic analysis and no standard nomenclature for the description of the samples.

A world map published in 1978 by Rawson and Ryan of LDGO shows the lithofacies of surficial sediments on all of the sea floors. Recently Floyd W. McCoy, LDGO, proposed that lithofacies maps of surficial sediments be prepared on the Project's base maps, using studies of about 3700 smear slides from cones in the LDGO sample library. The slides would be classified according to a 16-unit nomenclature (attach. 8) developed recently by Sample Library Curators.

McCoy discussed his proposal at the meeting, and, in the ensuing discussion, stated that it is not feasible to map the age of surficial sediments because the data are insufficient (only 20 percent of the samples in LDGO have been dated). He recommended converting the DSDP nomenclature to the "Curator's" nomenclature.

Regarding mapping of (pre-surficial) bedrock on the deep seafloor, McCoy felt that the sparse control would result in a misleading map. During the same discussion, Jim Gardner, USGS, Menlo Park, cautioned against mixing seismically derived information with data obtained from samples to compile a map showing both the distribution of surficial sediment lithofacies and the underlying stratigraphic units.

Compilation of map legends and preparation of the maps for publication were discussed at length by D. M. Kinney. He pointed out that the printed maps will be no more than 40 x 60 inches (102 x 142 cm) in size, a little wider than the Geographic maps. These limits will provide a map of manageable size that can be printed on most presses. Two sheets will be needed. The first sheet will show the map printed in color, an explanation (in color) with brief description of map units, an explanation of map symbols, a diagram correlating stratigraphic units of the map with other maps, and, in the title block, the names of the panel chairmen and the map compilers.

The second sheet, printed only in black, is to include a more detailed description of the map units, an index map of tectonic, structural, and/or geomorphic names, and certain place names used in the descriptions.

(Although some names such as those for rivers and mountains can be added to the base map, others cannot. If, for example, provinces or states are referred to, both their boundaries and names should be added to the index map.) Included on the second sheet will be lists of contributors and source materials, either of which may need a small-scale index map to outline areas. The second sheet probably can be designed to enable the user to cut the published descriptive part into page-sized sheets if desired.

It was noted that the absolute (radiometric) age column in the correlation diagram (attach. 9) is out of date, but new figures will become available in 1980. The correlation diagram in this report was revised by Panel Chairmen in Menlo Park, although the age column itself has not been changed. Some members of the group felt that regional ages should be shown.

Descriptions of map units will be placed in more than one column on at least some of the maps. It may be necessary, for instance, to use separate columns for different regions. Terman, in a trial compilation, used three columns to describe age, sedimentary-metamorphic rocks, and magmatic rocks (attach. 10) for China. Kinney emphasized that it is important to prepare clear and complete descriptions; details of format can be adjusted during final cartographic preparation.

The Deep Sea Drilling Program (DSDP) columns (attach. 11) have been compiled at a vertical scale of 1 cm:100 m and they are, perhaps, larger than necessary, but may be difficult to read if reduced as much as

50 percent. Even with a reduction of scale, however, some of those in the Northeast and Northwest quadrants must be placed on the second sheet to avoid cluttering the map. The significant logs are to appear near their drill sites on the map.

Kinney reviewed the hand-coloring process we anticipate using in order to make color negatives for the printers. As this will require very careful coloring of map units to obtain uniform printed colors, all coloring must be done by the same group. Colors cannot be changed once the colored negatives are made, so mistakes that are not caught in the initial coloring will be printed. Thus, it is important that the compilation copy be carefully labeled by letters or numbers keyed to a legend for the guidance of the coloring artist. A sheet illustrating how different colored pencils and inks will reproduce will be sent to panel chairmen within a few weeks.

Each panel is to arrange internal reviews of its own land geology; seafloor geology is to be added later when completed by LDGO. Overlap areas, of course, must be checked by all panels involved.

The updated compilation guide for the Geologic map comprises attachment 12.

Tectonic map

Discussions in Menlo Park clarified numerous points of doubt without greatly altering the proposed tectonic map contents (attach. 13). The principal change is the deletion of seismic epicenters, which will appear on the Plate-tectonics map.

Magnetic lineations and oceanic crustal age boundaries compiled on a Mercator projection have been received from LDGO, and prints were given to Panel Chairmen at Menlo Park. The lines are being transposed to the Map Project's base maps, and prints will be sent to the Panel Chairmen. No separate map was prepared for Antarctica, because, as Ms. Tchernitchin explained, all lineations appear on the overlap areas within the Southwest and Southeast Quadrant maps. When they are transposed to the Project's Antarctica base, copies will be sent to LDGO for review. The Lamont marine magnetic-reversal time scale on which the ocean crustal ages are based is included as attachment 14. Good progress in compiling the map has been made by the Southwest and Southeast Quadrant panels.

Geodynamics map

The objectives and contents of the Geodynamics map are unchanged, as shown by the compilation guide (attach. 15). Symbols for volcanoes are shown in attachment 16. The greatest need is for a basinwide gravity compilation; heat-flow data will be updated in a new compilation by WDC-A, which will be obtained when plotted in Boulder, Colorado. Many other data sets have been obtained. The Northwest Quadrant panel has experimented in combining these into a map and has made very good progress.

Hydrocarbon resources map

Following last year's decision to include geothermal energy sources in the Geodynamics map and the radioactive minerals in the Mineral Resources map, the former "energy" resources map is now designated the Hydrocarbon Resources map. Glen F. Brown, USGS, Reston, will be working part time compiling data for the Southeast Quadrant, and helping with support requirements for the other maps as needed.

The compilation guide (attach. 17) is unchanged from the one attached to the Northeast Quadrant map that was displayed last year at the Circum-Pacific Conference in Honolulu. As far as known, no work has been done by any Panel on compiling the tabular data, and the exact nature of what is to be listed has not been defined.

Mineral resources map

By: Philip W. Guild

The following points were addressed:

1. The geologic/structural base should show the lithologic nature of the rock units by patterns, suitably screened to reduce the patterns to a gray so that mineral-deposit information can stand out clearly. However, in accord with the suggestion that some pale colors would help to focus attention on critical of key units, the trial map of the Northeast Quadrant (displayed at Reston in 1978) was tinted for display at Honolulu. The map was examined again at this meeting; most chairmen seem to feel that more color would be advantageous; perhaps all units should have tints. As copy is prepared (see below), compilers are urged to experiment and send comments to Phil Guild, the Project Advisor on the Mineral Resources map.

Ozalid copies of the trial Northeast Quadrant Mineral Resources map are being prepared and will be distributed to the Quadrant Chairmen for their study, and, if they wish, guidance. Some difference of opinion exists as to the necessity or desirability of uniformity in the emphasis placed on individual units from quadrant to quadrant. After the chairmen have had a chance to review the Northeast Quadrant model, the Advisor would appreciate receiving comments.

2. Experience shows that the mineral-deposit symbols can be improved. New symbol sheets are being prepared (as of June 30) which will:

a) Use nominal sizes of 3, 1.7, and 1.2 mm respectively for large, medium, and small deposits.

b) Add "ticks" on the small-size symbols (as suggested by Jose Corvalan). However, some symbols without ticks will be provided also.

c) Use ticks in a somewhat heavier line weight than the perimeters to make them more legible.

d) Provide "Age ticks" that can be added by hand to indicate age of mineralization by adding ticks in one of eight positions. Instructions for their use and significance will be distributed with the symbol sheets when the latter are ready. Use of these age ticks is optional, but the consensus of the chairmen was that they should be tried.

3. The coding system presented last year has been modified slightly. Photographic copies of the "poster" displayed at Honolulu and in Menlo Park, and necessary revisions to the Instructions distributed in January 1977 are being prepared and will be distributed to Quadrant Chairmen.

4. The compilation of seafloor resources is the major problem still unresolved. It can be separated into two components:

a. Who should be responsible for obtaining and organizing the data? Is it better to use a "single source," such as an oceanographic institute, or should each Quadrant approach the matter individually? The USGS Office of Marine Geology has been asked for advice. After the meeting, Floyd McCoy of LDGO submitted a proposal for a contract to do this for us. The matter is being studied.

b. What to show and how to portray it?

i) Obviously, manganese nodules (and crusts) are the most important. Suggestions for ways to categorize them, showing content of the heavy metals, areas of concentration, and other data, have been made before--see reports of previous meetings--and various schemes have been used in maps by other organizations.

ii) Metalliferous sediments (even though these are not resources), locations of sulfides, hot spring discharges--perhaps with an indication of their temperatures--and any other features which may have metallogenic significance should be shown. As data are believed to be sparse, no problems of cartographic representation are anticipated.

iii) Near-shore detrital resources (Sn, Cr, others?) should be shown by the same symbols that are used for placer deposits on land.

iv) Marine phosphatic accumulations should be shown.

Quadrant Chairmen should gather and organize as much information as possible. We will advise them of developments on available data in Reston. Decisions as to precise symbology will be made in consultation with the Chairmen. Suggestions are welcome.

5. The steps used to produce the Northeast Quadrant Mineral Resources map were reviewed as possible guidance for the Chairmen:

a. Upon completion of scribing of the contacts and faults for the Geologic map, the scribe sheet was combined with a screened negative of the base map and printed on a greenline cronaflex, .007 inch. Thus, the base was gray, the geology black.

b. Lithologic symbols were inked by hand on the combined cronaflex print.

c. Deposit symbols were put on a separate greenline base.

d. The geologic sheet was again photographed through a screen. The base, now screened twice, was "held" as a subdued gray; the geology became a darker gray.

e. The deposit sheet was photographed without a screen, but the base was dropped. (This is the advantage of green; by proper use of filters it can be dropped or held.) The legend was placed on this sheet.

f. The negatives were combined and printed on "cronopaque," a white scale-stable plastic. The mineral-deposit data on map and legend were colored brightly, and the selected geologic units were tinted with the appropriate pencils.

Now that the Geologic maps are approaching final form and scribed copy is or shortly will be available, we should be able to complete the land areas of the Minerals resources maps rather quickly. Completion of the maps will, however, be delayed while the seafloor questions are resolved.

CONCLUSION

During the life of the Map Project, events have brought several revisions in the contents and titles of the map series. This has happened without any significant change to the map elements themselves. An accompanying check list (attach. 18) shows the compilation status of the mapped elements and indicates the maps in which, according to present plans, they will first appear in print. By compiling them separately (the Geologic maps excepted) and on scale-stable material, appropriate combinations can be made during the final stages of preparing maps for the printers.

ATTACHMENT 1
June 1979

ATTENDANCE

Chikao Nishiwaki	Inst. Int'l. Mineral Research and Development	Fujinomiya, Japan
Tamotsu Nozawa	Geological Survey of Japan	Tokyo, Japan
K. M. Dawson	Geological Survey of Canada	Vancouver, B.C.
K. J. Drummond	Mobil Exploration & Producing Co.	Dallas, TX
G. P. Salas	Consejo Recursos Minerales	Mexico City, D.F., Me
Jose Corvalan	Univeristy of Chile	Santiago, Chile
H. Fred Doutch	Bureau of Mineral Resources	Canberra, Australia
R. N. Richmond	Mineral Resources Department	Suva, Fiji
F. W. McCoy	Lamont-Doherty Geol. Observ.	Palisades, NY
Xenia Tchernitchin	Lamont-Doherty Geol. Observ.	Palisades, NY
Seiya Uyeda	Guest lecturer, M.I.T.	Boston, MA
Campbell Craddock	University of Wisconsin	Madison, WI
Herbert Meyers	NOAA-NGSDC	Boulder, CO
J. I. Ziony	USGS	Menlo Park, CA
R. G. Coleman	USGS	Menlo Park, CA
J. V. Gardner	USGS	Menlo Park, CA
E. H. Bailey	USGS	Menlo Park, CA
J. E. Case	USGS	Menlo Park, CA
W. P. Irwin	USGS	Menlo Park, CA
J. P. Albers	USGS	Menlo Park, CA
J. A. Reinemund	USGS	Reston, VA
D. M. Kinney	USGS	Reston, VA
P. W. Guild	USGS	Reston, VA
M. J. Terman	USGS	Reston, VA
J. I. Tracey, Jr.	USGS	Reston, VA
G. F. Brown	USGS	Reston, VA
P. W. Richards	USGS	Reston, VA

ATTACHMENT 2
June 1979

OPHIOLITE SUMMARY FOR THE CIRCUM-PACIFIC MAP PROJECT

MAY 1979

R. G. COLEMAN

The International Ophiolite Symposium held in Nicosia, Cyprus (April, 1979) was sponsored by the Cypriot Geological Survey, International Association of Volcanology and Chemistry of the Earth's Interior, IGCP Project 39 (Ophiolites) and the Hellenic Mining Company. In attendance were nearly 350 participants representing a truly international mix of scientists interested in ophiolites. Noteworthy was the seven-man delegation from China reporting new and interesting studies on ophiolites from the Tethys-Himalayan tectonic domain.

Important scientific aspects of the meeting are summarized below in separate categories.

Tracer studies on origin and tectonic setting of basalts associated with ophiolites continue to give results that conflict with geologic evidence. Even though there are sophisticated schemes using rare earths, Ti-Zr, Nb-Ta, and other ratios, these do not provide unequivocal answers as to the tectonic setting of the--that is, differentiating between island arc, back-arc basin, and mid-ocean ridge.

The concept of detachment metamorphism of oceanic crust received additional credibility at this meeting from numerous reports describing the actual mechanism of detaching hot-bottomed oceanic slabs and concomitant development of "freight-train" metamorphic rocks at the base of the peridotite. These thin, upside-down metamorphic zones can fix the time and style of detachment within the oceanic realm. Tied directly to this detachment concept is that of pervasive mantle deformation of the depleted harzburgites, which retain consistent imprints of flow lines related to ancient spreading ridges.

The mechanism of ophiolite emplacement received much discussion at this meeting. It would appear that emplacing ophiolites within subduction zones is very difficult, whereas large-scale transform faults, obduction, and gravity sliding of oceanic crust are more viable concepts. The lack of actualistic models inhibits the development of ophiolite-emplacement models.

Perhaps the most important aspect of the meeting was the development of concepts relating to the formation of ore deposits in the oceanic crust. The copper-bearing massive sulfide deposits of Cyprus are now considered to be formed as a result of hydrothermal activity near an ancient spreading ridge. Recent finds in the East Pacific Rise system of sulfide deposits associated with present-day deep ocean thermal systems provide a link between ancient and modern deposits. The presence of oceanographers at the meeting, looking at the Cyprus ore deposits and discussing their findings with economic geologists, indicates a coming-together of concepts on the possible potential of base-metal deposits in the oceanic realm.

Finally, the original Penrose definition of ophiolites is still accepted by the majority of workers, and this is due to the fact that it was a non-genetic statement. As it now stands, ophiolites may form in a variety of situations other than a mid-ocean spreading ridge. The main shortcoming of the definition is the inadequate detail concerning the sediments associated with ophiolites. Several discussions on this aspect of ophiolites revealed new and interesting concepts as to the environment under which ophiolites may form.

The next and final meeting of the IGCP Ophiolite Group will be in Italy in July 1980, directly preceding the International Geological Congress meeting in France. Steven Karamata has organized a metallogenic group to develop maps showing ore-deposit distribution within ophiolite terrains of the world. This group will probably evolve into a separate IGCP group.

ATTACHMENT 3
June 1979

Report from the National Geophysical & Solar-Terrestrial Data Center (NGSDC) and the Collated World Data Center-A (WDC-A) for Solid Earth Geophysics

The plotting of the seismicity maps for the five quadrants has been completed by NGSDC/WDC-A. The maps depict seven depth increments for earthquakes of magnitude 5.0 to 7.4 for the 1964-1977 interval and 7.5 and above for the 1897-1977 interval. Thus far, NGSDC has not been successful in plotting the earthquakes for the 1:20 million-scale Pacific Basin map.

In cooperation with the USGS, NGSDC is preparing a series of regional seismicity maps for the world. The first map is expected to be available before the end of the year and will depict magnitude and depth information for the mid-America region.

WDC-A for Solid Earth Geophysics, in cooperation with the Smithsonian Institution, has published a volcano map of the world. This map shows the frequency and recency of eruptions during the past 12,000 years. The data file used for that map is the same as that being used by the Circum-Pacific Map Project for the Plate-tectonics map.

WDC-A expects to have an updated version of the heat-flow file available within a few months. It has not yet been decided whether a new world heat-flow map will be published. However, any new data compiled since the heat-flow values were plotted for the five quadrants will be made available to the Panel Chairmen.

NGSDC is beginning to compile a computerized file of worldwide ocean core information in the newly recommended format and classification scheme recommended by the U.S. Core Curators. Thus far about 6,000 cores are in this system. The information will be made available to the Circum-Pacific project for compilation of its seafloor-lithology maps. Additionally, NGSDC has information concerning 70,000 other marine samples which could also be made available to support the effort. NGSDC will provide data and services as needed to Floyd McCoy of LDGO for compiling seafloor lithology maps for the Circum-Pacific Map Project.

In cooperation with the USGS and the U.S. Department of Energy, NGSDC is publishing a series of geothermal maps for the U.S. Three regional maps have been published this year. Additional, more detailed maps for many of the states will be produced during the next few years.

ATTACHMENT 4
June 1979

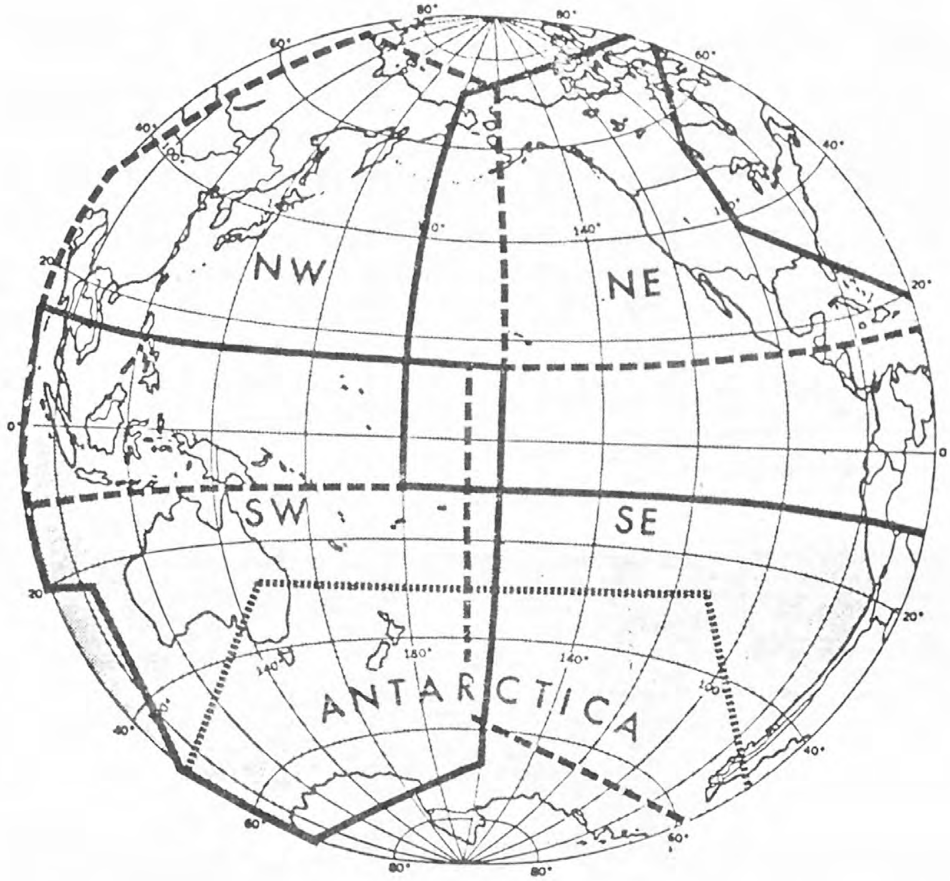
SUMMARY OF GEOCHRONOLOGY INFORMATION IN MARINE GEOLOGY DIGITAL INVENTORY

PETROS version 4.1 contains 4,499 "ocean floor" samples of which 1,576 have geochronologic dates worldwide. Ages given are relative ages down to the level of epoch (i.e., Paleocene). Some age codes are combinations of two epochs, and all material older than Mesozoic is lumped together. Positions on this file are limited in accuracy to 1°. Ages are for igneous rock samples rather than for sediment, and are radiometrically determined. Exact method of determination is not given in the file or accompanying documentation but may appear in the published literature, as may greater position accuracy; the file contains the identification of the special literature for each sample.

CLIMAP update 2 contains data from slightly more than 900 samples, 97 of which have accompanying ages. Ages are estimated in years, and upper and lower age errors are estimated. CLIMAP ages are primarily C^{14} dates derived from analysis of the tests of certain species. A species code is given to show which organism was used.

Other files containing age date information have not been digitized. They are in the form of technical reports or preliminary descriptions from Scripps (approx. 500; 238, if DSDP is excluded), Hawaii Institute of Geophysics (HIG) (approx. 400 samples) and the Japanese Oceanographic Data Center (15 samples). These files have relative age information similar to that given in PETROS and the Core Curators' file. Some are based on C^{14} or other radiometric methods, some are based on species identification, and some files do not indicate method used.

The total number of relative ages that we have is 2,497. The total number of absolute ages is 97. Additional information about each of the files can be obtained from NGSDC.



INDEX MAP OF THE PACIFIC BASIN

Showing boundaries (and overlap) of the quadrant maps and the Pacific Ocean boundary of the Antarctica map.

ATTACHMENT 6

June 1979

Plate-Tectonic Map
Compilation Guide

Seismic epicenters: Earthquakes of 5.0-7.4 magnitude during 1964-1977 are shown by circles. Epicenters of events 7.5 or greater magnitude are shown by triangles annotated with date and magnitude of shock. Depths, indicated by color: 0-70 km, 71-200 km, 201-300 km, 301-400 km, 401-500 km, 501-600 km, 601-700 km

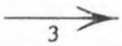
Volcanos: (all in one color)

✷ Active historically (generally within last 2000 years)

✵ Active during Holocene in pre-historic time

× Possibly active during Holocene: includes hot springs, geysers, solfataras, fumaroles, and marine eruptions

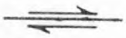
Plate-motion vectors:

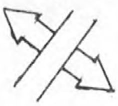


Direction and annual rate of plate movement in centimeters

Plate boundaries:


Subduction zone, teeth on upper plate


Strike-slip fault


Spreading center

ATTACHMENT 7
June 1979

LEGEND

(For SIO plot of surficial sediments - Jane Frazer)

Map Symbol	Sediment Type	Definition	Common Phrases Used in the Literature to Describe This Sediment	Notes and Exceptions
○	Rock and gravel	All sediments of which the predominant particle size is >2 mm.	rock gravel basalt manganese nodules chert chalk coral shells	Some stations so indicated may be unspecified dredges or photo stations so that this symbol may not represent the sediment. Where a layer of Mn nodules overlies clay or ooze, the station was shown as clay or ooze. A surface layer of Mn pavement, however, is shown as rock. Coral shows as rock.
—	Sand and/or silt	Sediments composed predominantly of particles between 2 mm and 4 μ in diameter.	sand silt volcanic ash coral sand Mn micronodules shell sand volcanic glass	In coding for the new data bank, we classified sediments according to Shepard's triangle, with "sand" or "silt" designations used only for samples with >90% coarse fraction. In coding for the old system, however, samples were classified as sand or silt if their coarse fraction was >50%. Most of the sand/silt samples shown on the Alaskan continental Shelf would now be coded as "mixed grain size" (+). Some calcareous oozes may be classified in the literature as sand (see note below).
+	Mud	Mixed grain size.	blue mud green mud black mud coral mud volcanic mud	Includes stations with turbidites and samples with 10-90% clay, the remainder sand and/or silt (as in Shepard's triangle and DSDP classification system). However, because of the widespread and often ambiguous use of the term "mud" some of these samples probably should be shown as clay. Some authors (e.g. Revelle, 1944) describe some sediments as "sandy mud" if they are predominantly sand or silt-sized particles of terrigenous origin. In coding for the old system we classified these as "mud", although some more properly should be classified as "sand" or "silt".
|	Clay	Fine-grained (diameter <4 μ) pelagic deposits, <30% skeletal remains of micro-organisms, <30% $CaCO_3$.	clay lutite brown clay red clay gray clay black clay predominant grain size < 4μ brown mud (if sampled at a depth >200 m, remote from any continents, in an area where most samples are pelagic sediment) calcareous clay } unless >30% skeletal siliceous clay } remains estimated	In shelf areas, sediments were classified as clay only if they were >90% clay size, or called "clay" as in "clayey mud". In the deep ocean, however, samples described as "red clay" or "pelagic clay" were classified as clay even if they had significant silt or sand fractions.
△	Siliceous ooze	All unindurated sediments containing at least 30% remains of siliceous organisms.	siliceous ooze diatom ooze radiolarian ooze diatom silt diatom clay } if estimated radiolarian mud } >30% skeletal remains	Some authors (e.g. the Challenger reports) identify samples as "siliceous ooze" if they contain >20% skeletal remains. Samples so described are included in this classification. As with calcareous ooze, many reports present grain size data only and ignore biogenic components. Siliceous clays and oozes may be very under-reported.
□	Calcareous ooze >30% $CaCO_3$	All unindurated sediments of sand size or finer containing an estimated 30% or more $CaCO_3$, except for sediments composed of shell or coral.	calcareous ooze globigerina ooze foram ooze coccolith ooze nannofossil ooze marl ooze chalk ooze marl mud foraminiferal sand pteropod silt calcilutite foraminiferal lutite } if $CaCO_3$ content clay with forams } estimated >30% white mud } if the station is white ooze } is in a geographical area calcareous sand } where (on the basis of data ooze } from nearby stations) calcareous coral sand } ooze is likely to be found.	Some stations shown as calcareous ooze, $CaCO_3$ >30% have $CaCO_3$ between 30-60% while others are samples described as "calcareous ooze" with no measured $CaCO_3$ values, or $CaCO_3$ reported as "moderate" or "low" (Lamont-Doherty Geological Observatory cores). Some calcareous sand samples classified as ooze may actually be coral or shell sand. Some samples categorized as ooze may actually have less than 30% $CaCO_3$ and should more properly be classified as clay or mud. One the other hand, some samples for which the only available data are grain size analyses may have been classified as clay, mud or sand when they are actually calcareous ooze.
◇	Calcareous ooze >60% $CaCO_3$			Stations shown as calcareous ooze, $CaCO_3$ >60% have $CaCO_3$ values reported either numerically or as "high carbonate" (Lamont-Doherty Geological Observatory cores). The computer-drawn diamonds sometimes look like wobbly circles, but are smaller than the circles denoting rock or gravel.

ATTACHMENT 8
June 1979

PROPOSED SEDIMENT CLASSIFICATION SCHEME
(F. W. McCoy)

TERRIGENOUS	TRANSITIONAL - MIXED	BIOGENIC
Gravel (a) [o] (b)		
Sand [-]		CALCAREOUS: [-] Calcareous Sand/Silt (d)
Volcanic Sand/Silt [-]		
Silt [-]	[¤] Marl	[o] Calcareous Ooze (e)
	Calcareous - Siliceous [o▲] Mud/Clay	
Silty Mud/Clay, (c) [+] Mud/Clay	[+△] Diatomaceous Silt	SILICEOUS: [▲] Diatomaceous Ooze (f)
	[△] Diatomaceous Mud/Clay	[△] Diatomaceous - Radiolarian Ooze
	[▲] Radiolarian Mud/Clay	[▲] Radiolarian Ooze

AUTHIGENIC

[ı] Pelagic Clay

(a) predominantly glacial erratics at high latitudes

(b) equivalent WDB sediment classification symbols; adaptation of these to this system will not be difficult using LDGO data from nearby sample localities as a guide

(c) "mud" and "clay" are considered synonymous terms for purposes of this classification, i.e. as a textural term denoting particle sizes in the clay - sized (<4μ) range

(d) includes foraminifera sands and silts, as well as mixtures of bioclastic debris associated with coral and algal reefs; can be an indicator of rapid deposition and current activity in deeper water depths

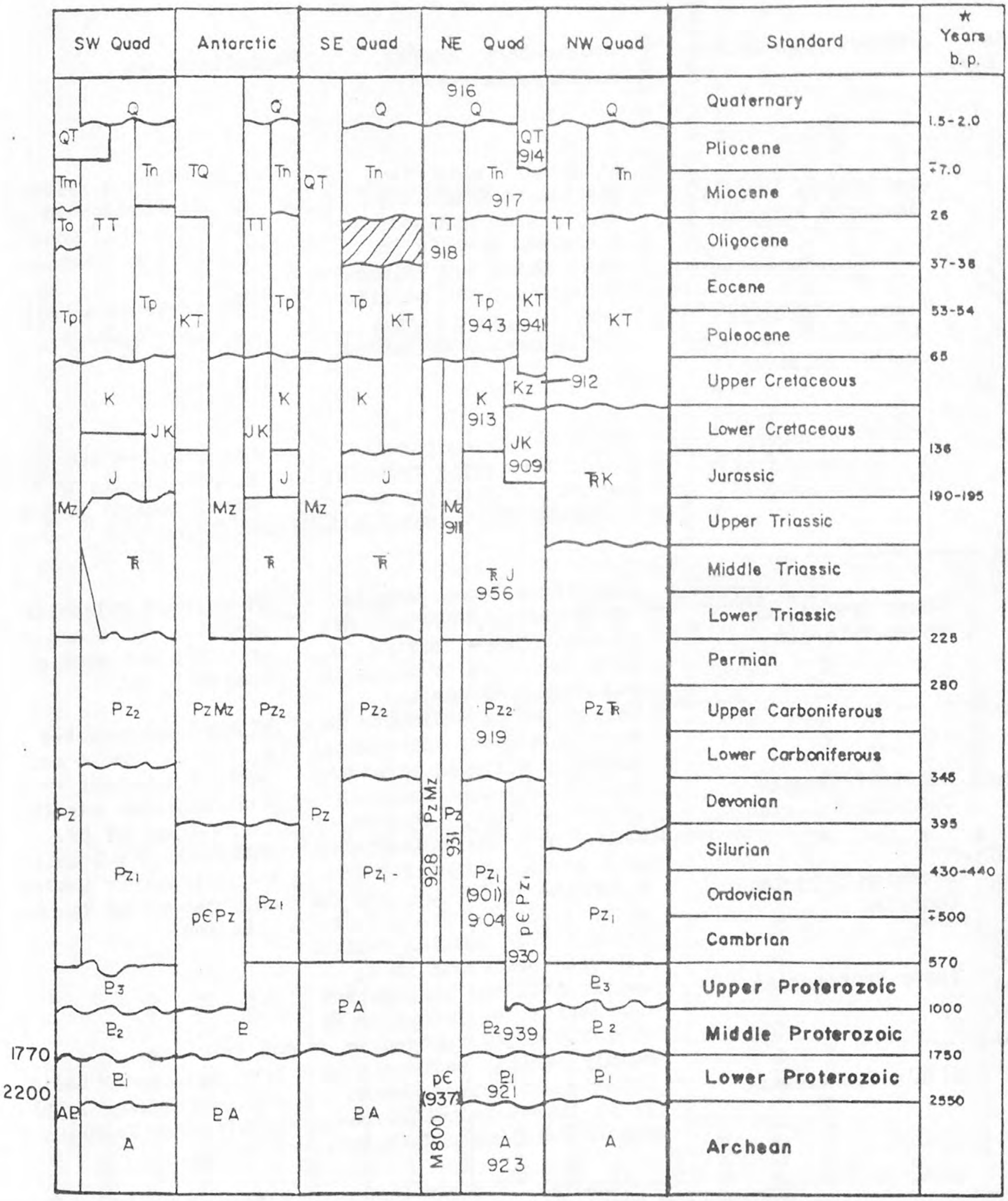
(e) this designation may be subdivided into four categories if warranted by smear slide data: calcareous nannoplankton ooze, foraminiferal ooze, foram - nanno ooze, and calcareous ooze (sediment containing <30% terrigenous detritus and >30% fine-grained, undistinguishable carbonate material [micrite]); it is not so subdivided here because the bulk, by far, of such sediment is expected to be foram - nanno oozes and limited areas of other sediment types in this subdivision could result in confused cartographic displays; their relative occurrances in sediment reflects dissolution gradients mainly, thus not being of primary interest to the goals of this project, and only partially reflects productivity effects

(f) biosiliceous oozes are subdivided into diatomaceous and radiolarian categories because these flora and fauna typify sediment in large, distinct areas and are important as indicators of modern and ancient climatic and productivity zones

CIRCUM PACIFIC MAP PROJECT

CORRELATION DIAGRAM FOR MAP LEGENDS

ATTACHMENT 9



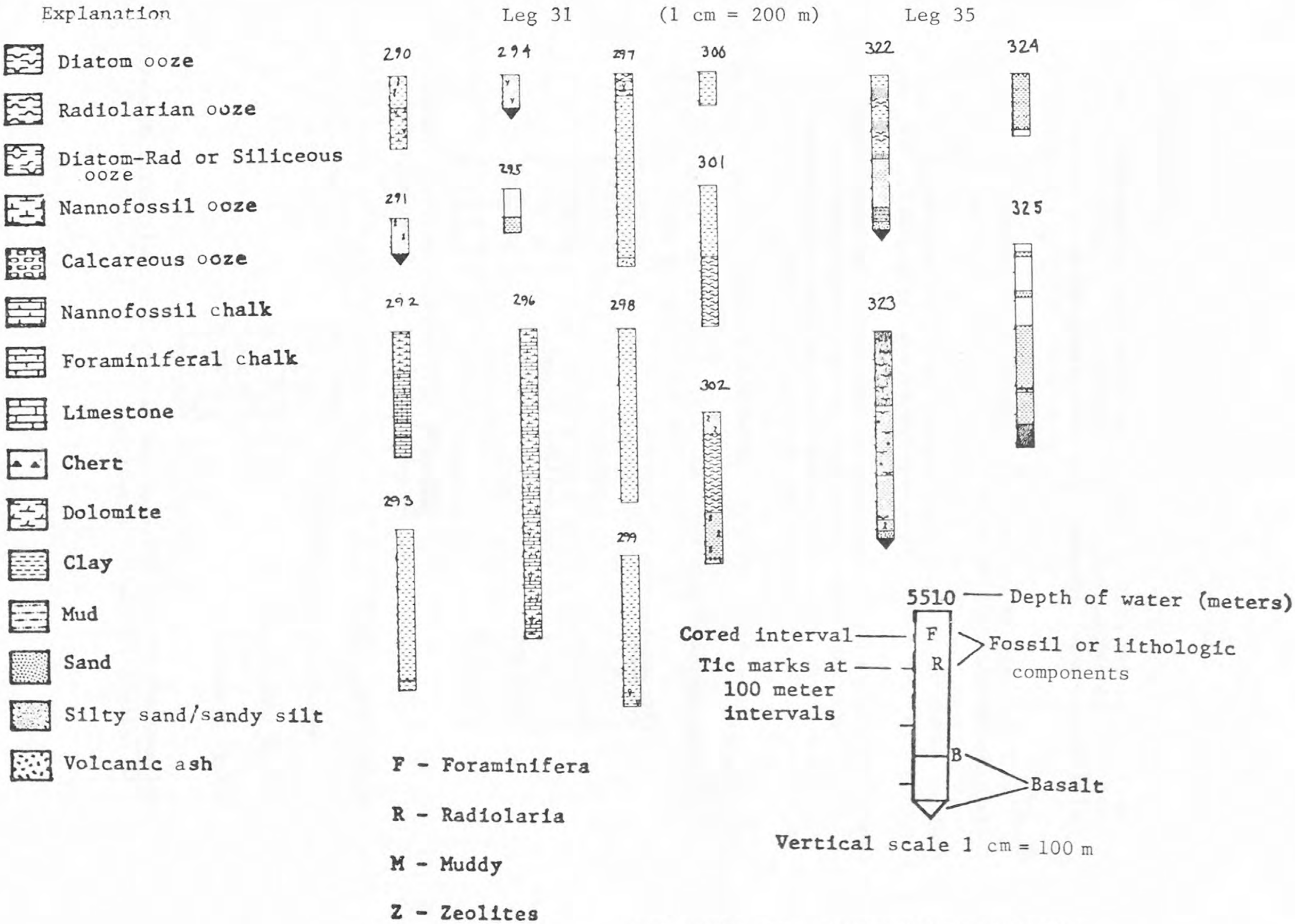
*Geological Society of London, 1964. The Phanerozoic time-scale; a symposium: Geol. Soc. London, Quart. Journ. v.120, suppl., p.260-262. In Precambriam time, year-scale is approximate, varies from Quadrant to Quadrant.

(901) color used by Drummond

904 color used on correlation diagram

GEOLOGIC MAP OF CHINA

Time in m.y.	Geologic age units	Sedimentary and/or metamorphic rocks	Magmatic rocks
0 – 3	Quaternary, locally includes Pliocene	Alluvial, lacustrine, glacial, and eolian; mostly fine-grained; reefs and paralic in South China and Taiwan.	Post-Miocene volcanic alkali basalts on cont mostly in NE; andesit Taiwan and Tibet.
3 – 26	Neogene, locally includes Quaternary and/or Paleogene	Continental and paralic sediments, some lignite; mostly marine in Taiwan.	Few areas of alkali ba in N and E China.
26 – 100	Paleogene-Upper Cretaceous, locally includes Neogene	Continental and paralic sediments, mostly redbeds; marine and slightly metamorphosed in Taiwan, Tibet.	Few granites and inter diate volcanis in Tibe some unmapped in E and NE China.
100 – 200	Lower Cretaceous-Upper Triassic	Continental and paralic sediments, widespread coal in South China; marine in Tibet and locally in north and southeast coast.	Widespread volcanics a granites in NE and SE; granites and some ultr mafics in SW.
200 – 300 – 400	Middle Triassic-Devonian/Silurian	Mainly marine sediments in south and west; continental clastics and coal in north; some metamorphic rocks in Inner Mongolia, Hsing-an.	Widespread granites in N, and SW; mafic and u mafic intrusions in N, and Tsinling; basalts i large areas of SW.
400 – 500 – 600	Devonian/Silurian-Cambrian	Mainly neritic sediments in in N and S; slightly metamorphosed in NW, SW, and SE; strongly in Hsing-an, Tsinling, and SE coastal region.	Interbedded volcanics, and ultramafic intusior only mapped in Nan Sha Tsinling.
600 – 700 – 800 – 900 – 1000	Upper Proterozoic	Littoral sediments in N; continental and glacial under neritic sediments in S; variably metamorphosed in SE and Tsinling.	-----
1000	Middle Proterozoic	Mainly neritic sediments in N; slightly metamorphosed in S; intensely metamorphosed in Tsinling and Kunlun.	Intermediate to basic v canics flanking Tsinlin granites in Tsinling an SE China.
2000	Lower Proterozoic	Moderately metamorphosed sediments; regionally metaphosed schists and gneisses.	Unmapped intermediate to basic volcanics; minor granites.
3000 – 4000 – 5000	Archean	Regionally metamorphosed gneisses, amphibolites, and granulites; some iron beds.	Migmatized and granitiz mostly unmapped.



ATTACHMENT 11. DSDP COLUMNAR SECTIONS

June 1979

GEOLOGIC MAP COMPILATION GUIDE

ON LAND

Contacts: Narrow black lines

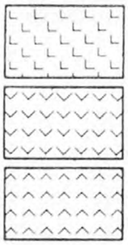
Faults: Wider black line or narrow red line (on compilation copy). Show only if contact between stratigraphic units.

Geologic age: To be shown by color. Maps are to be hand colored and photographed to make printing plates. Colors cannot be changed at proof stage, so compilation copy must clearly identify each map unit by color and symbol.

Lithology: To be shown by black pattern as follows.

Igneous rocks:

Extrusive

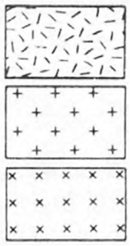


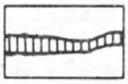
Felsic

Intermediate to mafic

Mafic

Intrusive





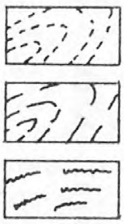
Ultramafic (includes oceanic igneous rocks)

Metamorphic rocks:

Low pressure, temperature

High temperature

High pressure



Sedimentary rocks: Black dotted pattern for continental deposits; no pattern for marine deposits.

ON SEAFLOOR

Bedrock: Show over shelf areas as on land if data are adequate and surficial sediments are thin and without known economic interest. How to show stratigraphic units (i.e., bedrock) beneath surficial sediments off the shelf has not been decided.

Surficial sediments: F. W. McCoy of LDGO is to prepare a lithofacies map of the surficial sediments following the classification of Attachment 8. The 16 units, presumably, will be represented by black patterns on the printed maps. Age data may be too sparse to show age of the surficial sediments.

DSDP logs: Selected logs to be shown on map close to symbol for the drill hole site; other logs to be placed on second sheet to prevent map clutter. Scale of logs already drawn is 1 cm equals 100 m; the patterns (attach. 11) will remain legible if reduced somewhat. Age colors used of land geology will be added to the columns; identify ages of units by symbols and colors on a print.

Fracture zones: To be shown by black lines and based on magnetic lineations maps prepared in LDGO.

FORMAT OF PUBLISHED MAPS

Sheet 1: To include all material printed in color copy.

1. Geologic map
2. Color boxes and brief description for each map unit
3. Diagram showing correlation of units with units on other maps.
4. Explanation of linework and symbols
5. Title block and acknowledgement of compilers, panel chairman

Sheet 2: To be printed in black.

1. Detailed description of map units
2. Index map, if needed, showing geographic names referred to in description (will be reduced to appropriate size for printing)
3. Sources of data listed, with optional index map showing areas covered by source materials
4. List of contributors, other than the compilers shown on Sheet 1.
5. DSDP columnar sections not appearing on Sheet 1.

(This sheet is to be designed so that it can be cut into page-size sheets.)

June 1979

TECTONIC MAP COMPILATION GUIDE

STRUCTURAL AND TECTONIC FEATURES
(black except as indicated)

Folds: Anticlinal axis: open closed numerous

Selected synclinal axis:

Faults, fracture zone: (red) extend from geologic map to include all faults; show displacement where known.

Normal , lateral , thrust , buried • • • •

Volcanos (red): Active ⊛ , inactive *

Salt domes (black): •

Diatremes (red): ⊕

Magnetic anomaly trends: Lineations on oceanic crust.

Age of oceanic crust: Show by color.

Geochronologic ages: Show at selected oceanic sites, particularly DSDP sites that reach oceanic basement, as K/Ar ages of basalt or paleontologic ages of overlying sediments.

Paleomagnetic data: Selected points showing azimuth (declination) arrows with vector (indication) figure at arrow head and geologic age symbol at base

Depth to basement rocks: Show by isopach lines (1, 3, 5 km) for continental areas to foot of continental slope, or by hundreds of meters (written 1, 2, 3, etc.) for ocean areas, except that travel time in 1/2 seconds to be used where necessary. Color of isopach lines to indicate age of basement (black if age is unknown).

BASEMENT ROCKS

Metamorphic rocks: As on geologic map

Intrusive igneous rocks: As on geologic map, except distinguish ultramafic intrusives (black) and oceanic igneous rocks* (purple) where possible and indicate geologic age of latter.

Submarine volcanic rocks: Basalts of oceanic crust

COVERING ROCKS

Deformed sedimentary rocks (those generally deemed to be too deformed to contain hydrocarbons): To be shown by screened pattern, the color to indicate age of deformation. Individual units can be shown as described for the platform strata (see below). Melange belts can be distinguished by an added line pattern, showing trends.

Basin deposits: To be shown by screen overprint, the color indicating age of oldest deposits.

Platform strata: The stratigraphic boundaries of major tectonic or lithologic significance to be shown in black, with parallel bands in color to indicate age of oldest unit, generally a regional unconformity.

Terrestrial volcanic rocks: As on geologic map

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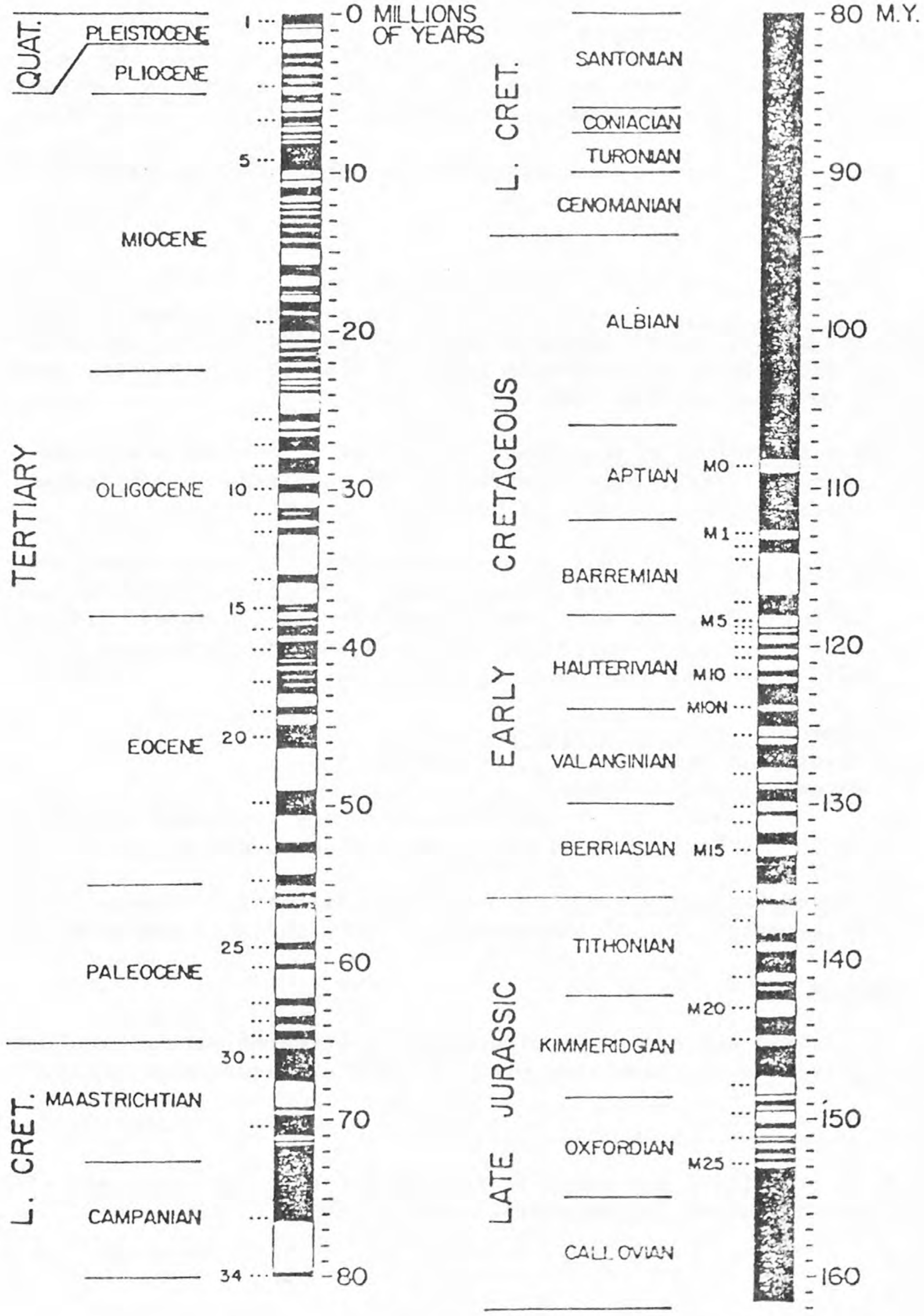
* Concerning term "oceanic igneous rocks," the following is taken from the May 5-8, 1975 Progress Report (p. 7).

> "(Edgar) Bailey and Robert Coleman suggested that the term 'ophiolite' not be used for a map unit of the Circum-Pacific maps; use instead 'oceanic lithospheric rocks' or 'oceanic igneous rocks' without age designation and not shown as intrusive. Corvalán pointed out that in South America it is not possible to separate 'oceanic lithospheric rocks' that are now on land from other ultramafic rocks. It was concluded that 'ultramafic rocks' would include ultramafic intrusives and oceanic igneous rocks on the geologic map, but intrusive and oceanic igneous rocks should be separated where possible for the tectonic map."

MARINE MAGNETIC REVERSAL TIME SCALE LAMONT (1976)

ATTACHMENT 14
June 1979



ATTACHMENT 15

June 1979

GEODYNAMICS AND GEOTHERMAL MAP COMPILATION GUIDE

Gravity: Bouguer anomalies to +250 and free-air anomalies elsewhere; interval 50 mg, except 25 mg between plus and minus 100 mg. (On printed map: yellow tints between +50 and -50 mg, red tints for positive values +50 mg and blue tints for negative values below -50 mg.)

Crustal thickness: Moho discontinuity depth-contour interval 5 km above 10 km and 1 km below 10 km.

Seismicity:

Epicenters--in gray, from plate-tectonic map.

Focal mechanisms--selected first-motion studies shown by beachball symbols; colors indicate depth ranges same as for epicenters on tectonic map; beachballs centered over locations where possible. Compiled by Fred Mauk and Art Tarr, USGS.

State of lithospheric stress: Principal stress vectors--show figure for plunge at arrow point and figure for magnitude in megapascals (MPa) at opposite end of symbol (1 MPa = 145 psi).

Heatflow: Show by spot data measurements with limiting values of 25, 50, 75, 100, 150, and 200 milliwatts/m^2; values above 200 mw/m^2 to be printed beside same symbol used for 150-200 mw/m^2. (Plots have been provided by World Data Center-A, Boulder, Colorado, and the Data Center is now compiling recent data.)

Geothermal convection systems:

Developed--steam (vapor), hot water

Potential--steam (vapor)

*hot water--indicate subsurface temperatures above 150° C.

*hot water--indicate subsurface temperatures 90°-150° C.

Volcanos (post-Miocene): A 3-fold classification showing form and activity by geometric symbol and rock type by color (Attachment 16).

Faults

Historic (in red): Displacement has occurred within the last 2,000 years and is associated with recorded earthquakes or creep.

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* As classified for the U.S. in USGS Circular 726; indicate if other basis is used for potential system.

Post-Miocene (in orange): Displacement not associated with historic record but recognized by scarps or water barriers in post-Miocene sediments, markedly linear mountain fronts, offset streams, or alinement of fault-caused depressions; entire fault should be shown in orange where local evidence indicates post-Miocene age.

Pre-Pliocene (in black): As on tectonic map

Lineaments

Trends suggested by satellite sensors, particularly Landsat, in brown.

FOR POSSIBLE INCLUSION AS SMALL-SCALE INSET MAPS

Magnetic anomalies: From satellite data, contour interval 2 gammas

Geoid anomalies: From satellite data, contour interval 5 m.

ATTACHMENT 16

June 1979

VOLCANOS FOR GEODYNAMICS MAP

(Data from: Data Sheets of the Post-Miocene Volcanoes of the World, and published geologic and tectonic maps.)

Activity

Active volcanos--solid symbol
Inactive volcanos--open symbol

(Active volcanoes have erupted during historic time, or have active solfataras or fumaroles, or are thought to have been eruptive during historic time or the past 2000 years.)

	Rock type: Andesitic, dacitic, or rhyolitic (± basalt)	Basalt (little or none of more silicic rocks)	Alkali basalt, trachyte, phonolite	Unknown
Form (central vent)				
Lava volcano (shield, cone, dome)	■	□ ■	□ ■	
Pyroclastic volcano (cinder cone, pyroclastic flows)	△ ▲	△ ▲	△ ▲	
Compound (strato) volcano	○ ●	○ ●	○ ●	
Type unknown or unreported (includes submarine eruptions)	+		+	+
Colors	Red	Blue	Purple	Black

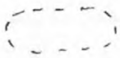
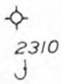
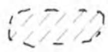
June 1979

HYDROCARBON RESOURCES MAP COMPILATION GUIDE

Background map: To be adapted from the Geologic or Tectonic Maps showing:

1. Structural features, selected so as to make a legible map.
2. Isopach lines in color representing age of basement rock.
3. Metamorphic and plutonic rocks as one basement rock unit.
4. Volcanic rocks as one unit; delete obvious volcanic rock cover on basement rock.
5. Continental strata distinguished by dotted pattern, as on geologic map.
6. Salt domes and, probably, geopressured areas.

Energy resources:

	Suggested linework for compilation			
	Area of many small fields	Large or coalescing fields	Small field	Color
Oil (or oil and gas)			●	green
Gas		(as above)		red
Dry hole (total depth in meters and age of lowest strata penetrated)				black
Oil (tar) sands				green
Oil shale				blue
Coal basins or fields				
Anthracite (and semi-anthracite)			▲	brown
Bituminous			▼	brown
Subbituminous			■	brown
Lignite			●	brown
Coal (rank of coal unknown)			×	brown

ATTACHMENT 18
June 1979

CIRCUM-PACIFIC MAP CONTENT
SUMMARY CHECK LIST
(Showing map series on which element first appears)

Compilation* status		GEOLOGIC	"PLATE" TECT.	TECTONIC	GEODYNAMIC	MINERALS	HYDR
	Sedimentary rocks	X					
—	Seafloor surficial sediments	X					
	Igneous rocks	X					
	Metamorphic rocks	X					
+	DSDP columnar sections	X					
	Faults	X					
	Fracture zones (seafloor)		X				
	Folds			X			
	Salt domes			X			
	Diatremes			X			
—	Isopachs--seafloor sediments			X			
	Isopachs--continental areas			X			
+	Volcanoes--Holocene activity		X				
	Volcanoes--post-Miocene, active/inactive			X			
	Volcanoes--post-Miocene, acc. to form, activity, chemistry				X		
	Oceanic crustal areas		X				
+	Age of oceanic crust		?	X			
+	Seismic epicenters		X				
	Subduction zones, spreading centers, transforms		X				
—	Plate-motion vectors		X				
+	Magnetic lineations		?	X			
	Geochronologic data			X			
	Paleomagnetic data			X			
+	Focal mechanisms (beachballs)				X		
	Crustal thickness				X		
—	Gravity				X		
+	Heatflow, spot data				X		
	Lithospheric stress				X		
	Holocene fault movement				X		
	Major lineaments				X		
	Geothermal sites				X		
	Mineral localities on land					X	
	Mineralized areas on seafloor					X	
	Oil, gas fields						X
	Oil shale, oil (tar) sands						X
	Coal-bearing areas						X

* Items to be compiled by individual Panels except those marked: —, to be compiled basin-wide, and +, already compiled, or mostly compiled basin-wide

CIRCUM - PACIFIC COUNCIL
FOR
ENERGY AND MINERAL RESOURCES

CIRCUM - PACIFIC COUNCIL
FOR
ENERGY AND MINERAL RESOURCES
MAP PROJECT

PLEASE REPLY TO: Office of International Geo
345 Middlefield Road, MS 52
Menlo Park, CA 94025
February 14, 1980

Memorandum

To: Panel and Committee Members, Contributors, Interested Parties

From: Warren O. Addicott, Deputy Chairman, Map Project

Subject: Status reports, Circum-Pacific Map Project

Enclosed please find one copy of STATUS OF THE CIRCUM-PACIFIC MAP PROJECT (U.S. Geological Survey Open File Report 79-1561 by Paul W. Richards) and and interim report based on a December, 1979, project review. I call your attention to an insert in OF-79-1561 concerning compilation of tectonic maps for the project by H. F. Doutch. This document was inadvertently omitted from the Open File Report which was issued in October, 1979.

We are currently making arrangements for the annual Panel Chairmen's Meeting to be held in Menlo Park, California, during the first or second week in May, 1980. More information on the meeting will be furnished to the Map Panels once the final dates are settled.

Warren O. Addicott

Warren O. Addicott

Summary of a Circum-Pacific Map Review Held in
Reston, Virginia, December 7, 1979

Introduction

A review and critique of the Circum-Pacific Map Project was held in Reston, Virginia, on December 7, 1979, from 9 a.m. until 12 noon. Nineteen geologists, principally from the Geological Survey, participated in the presentation and round-table discussion. The meeting followed a three-day period of internal review and planning by Office of International Geology personnel.

International Group Chairman John A. Reinemund reviewed the goals, organization, and funding of this cooperative international project. Products include plate-tectonic, geologic, tectonic, minerals, energy, and geodynamics maps covering Antarctica and the four quadrants of the Pacific. The Geological Survey's role in this international endeavour involves 1) project coordination and 2) basic data contributions, principally to the Northeast Quadrant maps. Reinemund noted that the philosophy in developing these thematic maps is to present basic data with minimal interpretation. The basic map series is at a 1:10 million scale. The final 1:20 million Pacific Basin map will combine tectonics with an interpretive view of dynamic processes in the earth's crust relating to the formation of energy and mineral resources.

Project Status

Signaficant progress in readying the geological map series for publication has been realized since the May, 1979, panel chairman's meeting. [summarized in U.S. Geological Survey Open File Report 79-1561, 1979]. Completion and publication of the Plate-Tectonic and Geological Maps is close at hand with compilation of the final elements of each series (plate motion vectors and sea floor sediments) scheduled for calendar year 1980. The Plate-Tectonic Map will be ready for review and publication during the first half of the year; the Geological Map should be ready at year end.

The map series and status of compilation were reviewed by M. J. Terman, Chief of the Branch of Middle Eastern and Asian Geology, and P. W. Richards, outgoing International Deputy Chairman and Project Chief, with the assistance of P. W. Guild, G. F. Brown, and G. W. Moore. Map elements and the status of compilation are shown in attachment 1; specific topics considered during the meetings are summarized below.

Plate-Tectonic Map. The first of the thematic map series is planned for publication in 1980. Basic data sets (seismic epicenters, Holocene volcanoes, and magnetic lineations) are completed and ready for publication. George Moore has completed a plate motion map for the northeast quadrant showing absolute motion of the plates and relative motion at plate boundaries and spreading centers. This map is being disributed to panel chairmen for review and comment (Moore will next compile plate motion vectors for the southeast quadrant). Once this element is finalized and compilation of plate-related faults is completed and incorporated in the maps, a color proof will be made and will be circulated to panel chairmen for review. The target date for the northeast color proof is April. The title for this series is tentative; an alternative suggestion is Mesozoic/Cenozoic Evolution of the Ocean

Basins. K. J. Drummond, Northeast Panel Chairman, has agreed to prepare a 1:20 million Pacific Basin Plate-Tectonic Map after the quadrant maps are completed.

Geologic Map. The second map in the geological series is nearing completion. Onshore geology has been compiled by all of the panels; a few problems need to be resolved, including areas where sheets overlap. Mapping of sea floor sediments, the final map element that needs to be completed, was initiated in November. It is being carried out by Floyd McCoy of Lamont Doherty Geological Observatory utilizing a new standarized classification system and small-slide analysis of surface material in the Lamont cores. The 16 sediment categories of this classification provide a significant degree of refinement over the previously obtained data set from Scripps Institution of Oceanography. The Scripps data, as well as core data from six other institutions will be incorporated into the set of Lamont core data being examined by McCoy where possible. The Northeast Quadrant Map is scheduled for completion in March, 1980; target date for completion for the final map is November, 1980. DSDP holes and significant stratigraphic boundaries such as limits of turbidite fans and equatorial carbonate area, will be added to the sea floor mapping by George Moore.

Tectonic Map. Consideration was given to combining elements of this map with the geologic map into a combined geotectonic map as a means of reducing the overall number of maps in the series. The advice of the participants, however, was to maintain the tectonic map as a separate entity in part owing to the potential problem of entering too much data onto individual maps. This possibility was also considered by the Panel Chairmen in May, 1979, and was likewise rejected. Oceanic crustal ages, recently compiled by W. L. Pitman, III, Xenia Golovchenko and colleagues of Lamont Doherty Geological Observatory, will be included on this map. Sea floor sediment isopachs recently compiled by W. J. Ludwig, and R. E. Houtz of Lamont have been made available to the project. Still to be compiled are geochronolocical data.

Resources Maps. The Minerals Resources Map of the Northeast Quadrant was displayed by P. W. Guild, Project Advisor on Minerals Resource Maps. The land portion of this map is complete and has been circuulated to other panels both for review and to serve as a guide in completing the other maps. Certain new and modified symbols have been developed for greater accuracy in denoting size and age of mineral deposit. Still to be completed is the sea floor minerals resource component. Project funds for a manganese nodule map of the Pacific Basin have been budgeted and a contract will be let in 1980 to complete this part of the map.

A hydrocarbon resource map for the Northeast Quadrant has been completed and reviewed. A color proof of the map has been sent to other panels to serve as a guide in compilation of the other quadrants. The Southeast Quadrant map, being compiled by G. F. Brown, will be completed and ready for review early in 1980. Tabular data indicating petroleum basins, size of oil and gas fields, age of hydrocarbon deposits, and grade of deposits will be included in oceanic areas of the map along the margins. By early 1980, initial maps in this series should be completed and distributed for panel review although the Southwest Quadrant map may be delayed.

Geodynamics Map. The last map in the 1:10 million series will include gravity as the fundamental unit; free air anomalies will be shown for oceanic areas and Bouguer anomalies for land areas. Compilation of gravity data has not begun, sources of basin-wide gravity mapping are being actively considered; the possiblility of utilizing stellite-derived data was discussed by Paul Lowman of NASA's Earth Resources Group. Although focal mechanisms ("beachballs") and heat flow data are completed, much of the basic compilation remains to be completed as indicated in attachment A.

Pacific Basin Map. The final map in the series will be a 1:20 million basin-wide map showing geology and an interpretive view of those dynamic processes in the crust that can be related to the formation of mineral and energy resources. Although the basic format of this map has been determined, specific map elements have not been finalized.

Publication

The Plate-Tectonic Map will be completed during the first half of calendar year 1980 and ready for publication. The Northeast Quadrant Map will be issued first and will be followed, in close succession, by the four other maps. Next in the series will be the Geological Map; compilation should be completed toward the end of 1980.

Reinemund announced that the American Association of Petroleum Geologists (AAPG) is prepared to continue publication having recouped their initial investment in the geographic and base map series. Funding for the forthcoming active plate-tectonic map through the Department of Energy, is assured at least in part and there are indications that additional funding will continue in the future.

Map Coordination Consultant D. M. Kinney outlined steps in the preparation of maps for publication and showed a cost break-down for these functions:

Planning---------------	20 percent
Scribing---------------	30 percent
Stickup and type-------	30 percent
Peeling----------------	15 percent
Proofing---------------	5 percent
	100 percent

Among the kinds of map preparation available to the project, the author-generated colored map copy tentatively approved at the May, 1979, Map Project meeting was discussed. This method is advantageous in reducing costs and time to publication, especially the latter. There is, however, a trade-off in poorer quality of color rendition with the hand-coloring process. The peel and paint method, a relatively new cartographic-assisted technique which has some of the above advantages, provides good color quality. Both of these differ from the conventional open window or peel-coat method in that corrections can not be made once the negative has been made.

Attachment 1

CIRCUM-PACIFIC MAP SERIES - SUMMARY CHECK LIST
(showing map components, primary map occurrence, and compilation status:
● - compiled; ■ - partially compiled; 0 - not compiled)

Map	Component	Plate-Tectonic	Geologic	Tectonic	Geodynamic
PLATE-TECTONIC	Fracture zones	●			
	Seismic epicenters	●			
	Subduction zones, spreading centers, transforms	●			
	Plate motion vectors	■			
	Plate-related faults	■			
	Magnetic lineations	●			
	Volcanoes - Holocene activity	●			
GEOLOGIC	Sedimentary rocks		●		
	Seafloor surficial sediments		■		
	Igneous rocks		●		
	Metamorphic rocks		●		
	DSDP columnar sections		■		
	Faults		●		
TECTONIC	Volcanoes--post-Miocene, active/inactive			●	
	Folds			●	
	Salt domes			0	
	Diatremes			0	
	Isopachs - sea floor sediments				■
	Isopachs - continental areas				●
	Age of oceanic crust				●
	Geochronologic data				0
	Paleomagnetic data				0
GEODYNAMICS	Volcanoes--post-Miocene, acc. to form, activity, chemistry				■
	Focal mechanisms (beachballs)				●
	Crustal thickness				0
	Gravity				0
	Heatflow, spot data				●
	Lithospheric stress				0
	Holocene fault movement				■
	Major lineations				■
	Geothermal sites				0

Map	Component	Compilation Status	
		Minerals	Hydrocarbons
MINERALS	Mineral localities on land--------	●	
	Mineralized areas on seafloor-----	0	
HYDROCARBONS	Oil, gas fields-------------------		■
	Oil shale, oil (tar) sands--------		■
	Coal bearing areas----------------		■

Attachment 2

CIRCUM-PACIFIC MAP PROJECT - STATUS AS OF DECEMBER, 1979

MAP SERIES	STATUS AND COMMENTS
Geographic Maps (5 at 1:10 million scale; 1 at 1:20 million scale)	Published
Base Maps (5 at 1:10 million scale; 1 at 1:20 million scale)	Published
Plate-Tectonic (6 maps)	First element (plate motion vectors) to be completed in early 1980. Ready for publication first half of 1980.
Geologic (5 maps)	Land areas compiled; sea floor sediment mapping in progress with completion by late 1980. Publication to follow Plate-Tectonic Maps. Northeast quadrant: sea floor compilation to be completed during 1980; other elements compiled. Other quadrants: to follow NE; sea floor compilation to be completed by year end 1980.
Tectonic (5 maps)	Crustal ages compiled; sea floor isopachs compiled; geochronologic and paleomagnetic data to be compiled. To follow geologic map. Northeast quadrant: 50 percent compiled; major work to follow completion of geologic map. Other quadrants: about same stage as NE excepting SW is farther along.
Geodynamics (5 maps)	Seismic epicenters, first motion studies, and heat flow data compiled; gravity, lithospheric stress to be compiled. Northeast quadrant: About 60 percent compiled. Other quadrants: About same stage as NE.
Hydrocarbon Resources (5 maps)	Northeast quadrant: compiled. proofs to other panels as a guide; minor revision required. Other quadrants: southeast to be completed in first half 1980; status of NW and SW not know. Antarctica hydrocarbons and minerals maps to be combined.

Minerals Resources (4 maps)	Contract for sea floor minerals mapping to be let in 1980; land areas compiled. <u>Northeast quadrant</u>: land areas compiled, undergoing minor revision and updating. Sent to other panels as a guide. <u>Other quadrants</u>: land areas compiled or nearly compiled; awaiting sea floor mapping.
Pacific Basin Map (1 map)	To conclude series showing relation of minerals and energy resources to geology and dynamic processes. Compilation 25 percent completed.