

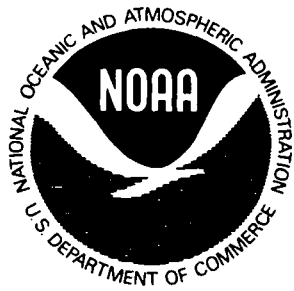


# Bibliography and Index to Literature on Manganese Nodules (1874-1975)

Key to Geophysical Records Documentation No. 6

U.S. Department of Commerce  
National Oceanic and Atmospheric Administration  
Environmental Data Service  
National Geophysical and Solar-Terrestrial Data Center  
Boulder, Colorado  
April 1976

**COVER:** *Ocean bottom photograph showing dense manganese nodule deposits at 24°22.3' S., 163°40.6' W., 5350-meter depth, taken during TANGAROA cruise in 1974. Photo courtesy of New Zealand Oceanographic Institute, Department of Scientific and Industrial Research, Wellington, New Zealand.*



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**Key to Geophysical Records Documentation No. 6**

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IDOE-NSF Manganese Nodule Technical Report No. 14

National Oceanic and Atmospheric Administration

Environmental Data Service

National Geophysical and Solar-Terrestrial Data Center

Boulder, Colorado

April 1976



## F O R E W O R D

The National Geophysical and Solar-Terrestrial Data Center serves as the data management center for the National Science Foundation's Seabed Assessment Program of the International Decade of Ocean Exploration (IDOE). The Manganese Nodule Project within the Seabed Assessment Program consists of a multi-institutional approach to the solution of basic problems concerning the origin and chemical composition of ferromanganese deposits of potential economic value. Most of the "data" on manganese nodules appears in research reports in the technical literature and thus this bibliography and the detailed subject index serve as one of the keys to the extant data in this field.



## PREFACE

The compilation of this bibliography and index of literature pertaining to manganese nodule research has been undertaken in response to an awareness of the rapidly increasing volume of publications on the subject, and to the need for easier access to information on specific nodule research topics. The only bibliographies published to date which encompass this broad field are those of Glasby (1972b, 1972c), and they appeared prior to the inception of the IDOE-NSF Ferromanganese Research Program. The present bibliography is essentially an updated version of the work of Glasby, with a decreased emphasis on terrestrial manganese occurrences, and an increased emphasis on trace elements in the waters and sediments associated with ferromanganese deposits.

The majority of the bibliographic entries have appeared in English-language publications, but we have also included all foreign references known to us; these are mostly German and Russian, with some French and Japanese entries. Considering English-language references appearing in the most widely circulated technical journals, the entry list is reasonably complete through 1974. Compilation of the main bibliography was completed during the early months of 1975, but a lag time in locating the more obscure references or in the appearance of translated versions of foreign-language papers partly accounts for there being fewer 1974 than 1973 entries. The addendum, completed in January 1976, brings the situation forward by about a year.

Ms. Lora Hingston and Ms. Wendy Triantafelo typed the manuscript of this work. Our thanks are extended to them for displaying meticulous dedication to such a tedious task. Ms. Ethel McAfee

provided assistance with bibliographic and index formats. Our work was funded in part by State of Hawaii/Marine Affairs Coordinator Task No. 35 and by IDOE-NSF Grant Nos. ID075/12953 and ID072/06428.

Honolulu, Hawaii

M. A. Meylan  
D. K. Dugolinsky  
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February 20, 1976



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PART I

BIBLIOGRAPHY



## INTRODUCTION

Part I consists of a listing of references pertaining to the many aspects of manganese nodule research, arranged alphabetically by author. There are 1,734 entries, ranging in publication date from 1874 to 1975. More than half of the publications listed have appeared in the last decade (see Table 1, a chronological list of the frequency of occurrence of bibliographic entry publication dates). But it must be pointed out that, although a proliferation of interest in nodules and reporting of scientific results certainly exists, many of the categories of papers only peripherally related to manganese nodule research are represented primarily by recent significant or review articles.

Most of the recently acquired references were located by a search of the more widely circulated, and hence more readily available technical journals in the fields of geology and geochemistry. The reference lists published in Marine Geology and Deep-Sea Research were also major sources of pertinent articles and books. Coverage on manganese mineralogy was greatly improved by consulting a manuscript authored by Roger G. Burns and Virginia Mee Burns (in press, ch. 7 in G.P. Glasby, Marine Manganese Deposits, Elsevier). The quadrennial U. S. reports to IUGG (Transactions, American Geophysical Union, 1967, v. 48, no. 2 and 1971, v. 52, nos. 5 and 6) supplied many references in the fields of trace element and radioisotope marine geochemistry. The recent bibliography of Wang and Quintero (1974) furnished a number of references on the topic of economic potential of manganese nodules. Also included in this bibliography are references representing abstracts of papers presented at significant national meetings, particularly those of the Geological Society of America and American Geophysical Union.

TABLE 1

FREQUENCY OF OCCURRENCE  
BIBLIOGRAPHIC ENTRY PUBLICATION DATES

<u>Publication Date</u>	<u>Frequency of Occurrence</u>	<u>Publication Date</u>	<u>Frequency of Occurrence</u>
1874 . . . . .	1	1936 . . . . .	8
1876 . . . . .	2	1937 . . . . .	.8
1877 . . . . .	1	1938 . . . . .	4
1878 . . . . .	2	1939 . . . . .	3
1881 . . . . .	4	1940 . . . . .	6
1882 . . . . .	1	1941 . . . . .	5
1883 . . . . .	1	1942 . . . . .	6
1884 . . . . .	2	1943 . . . . .	6
1885 . . . . .	1	1944 . . . . .	3
1887 . . . . .	2	1945 . . . . .	4
1891 . . . . .	2	1946 . . . . .	2
1892 . . . . .	2	1947 . . . . .	3
1894 . . . . .	1	1948 . . . . .	7
1898 . . . . .	1	1949 . . . . .	7
1900 . . . . .	1	1950 . . . . .	12
1901 . . . . .	2	1951 . . . . .	8
1902 . . . . .	1	1952 . . . . .	12
1903 . . . . .	1	1953 . . . . .	12
1906 . . . . .	2	1954 . . . . .	11
1908 . . . . .	2	1955 . . . . .	17
1909 . . . . .	2	1956 . . . . .	15
1910 . . . . .	5	1957 . . . . .	13
1914 . . . . .	1	1958 . . . . .	17
1915 . . . . .	1	1959 . . . . .	32
1916 . . . . .	2	1960 . . . . .	37
1917 . . . . .	1	1961 . . . . .	25
1918 . . . . .	1	1962 . . . . .	39
1919 . . . . .	1	1963 . . . . .	34
1920 . . . . .	1	1964 . . . . .	58
1922 . . . . .	2	1965 . . . . .	67
1923 . . . . .	2	1966 . . . . .	87
1924 . . . . .	4	1967 . . . . .	.107
1925 . . . . .	1	1968 . . . . .	.104
1927 . . . . .	2	1969 . . . . .	.115
1928 . . . . .	5	1970 . . . . .	.146
1929 . . . . .	3	1971 . . . . .	.154
1930 . . . . .	3	1972 . . . . .	.197
1931 . . . . .	2	1973 . . . . .	.171
1932 . . . . .	5	1974 . . . . .	.79
1934 . . . . .	4	1975 . . . . .	.7
1935 . . . . .	6		

Total number of entries = 1,734.

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**PART II**

**INDEX**



## INTRODUCTION

Part II consists of a subject index which is primarily title-keyed, i.e., the selection of index category (or categories) for each reference in the bibliography was based on subject information supplied by the title. In many cases, however, indexing was accomplished after examination of the contents of a reference. This was particularly true when a title was very generalized or ambiguous.

The literature pertaining to manganese nodule research has been arbitrarily subdivided into 26 major, but partly overlapping, categories (41 sections when sub-categories are counted). A listing of index sections follows this Introduction. All references in the bibliography are cited in at least one index section, and many are found in more than one section. The selection of index category was, of course, a somewhat subjective decision, but it is hoped that each reference is listed in those subject areas for which it is a significant source of observations, data, or concepts.

Information supplied opposite the author list in the index essentially consists of a shortened version of the title, augmented in many cases with additional information regarding the subject matter of the reference. Many foreign titles, particularly German and French, are represented by translated versions of their titles or contents. In order to facilitate scanning of the subject column, many commonly used words have been abbreviated; a list of abbreviations follows the list of index sections.



## STRUCTURE OF INDEX

- 1 - MANGANESE NODULES--GENERAL
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- b- SYMPOSIUMS and COLLECTIONS of PAPERS
- 3 - DATA COLLECTIONS and EXPEDITION REPORTS
- 4 - MARINE DISTRIBUTION and OCCURRENCE of NODULES and MANGANIFEROUS SEDIMENTS
- a- BOTTOM PHOTOGRAPHY OF NODULES
- b- PACIFIC OCEAN
- c- ATLANTIC OCEAN
- d- INDIAN OCEAN and RED SEA
- e- ANTARCTIC OCEAN
- f- ARCTIC OCEAN
- g- MEDITERRANEAN and EUROPEAN SEAS
- h- GULF of MEXICO and CARIBBEAN SEA
- i- WORLDWIDE
- 5 - FRESHWATER NODULES, CONCRETIONS, and MANGANIFEROUS SEDIMENTS
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- 13 - PETROLOGY and CHEMISTRY of ROCKS ASSOCIATED with MANGANESE DEPOSITS
- 14a- MINERALOGY of MANGANESE NODULES
  - b- MANGANESE MINERALS
- 15 - GEOCHEMISTRY and STRUCTURE of IRON and MANGANESE OXIDES and HYDROXIDES
- 16 - GEOCHEMICAL PROCESSES and ENVIRONMENTAL CONTROLS RELEVANT to Mn-NODULE FORMATION
- 17 - FORMATION and ORIGIN of MANGANESE ACCUMULATIONS--GENERAL
- 18a- MARINE METALLOGENIC DEPOSITS and FERROMANGANOAN SEDIMENTS
  - b- ASSOCIATION of Mn-NODULES with SUBMARINE VOLCANICS; VOLCANIC ORIGIN of Mn-NODULES and NODULE METALS
- 19a- BIOGEOCHEMISTRY of MANGANESE and OTHER ELEMENTS
  - b- BIOLOGICAL ORIGIN of NODULES; ASSOCIATION of ORGANISMS and Mn-NODULES
- 20 - INTERNAL STRUCTURE and EXTERNAL MORPHOLOGY of NODULES
- 21 - RADIOGEOCHEMISTRY of NODULES; RATES of NODULE GROWTH
- 22 - INSTRUMENTAL and ANALYTICAL TECHNIQUES for STUDYING NODULES
- 23 - COSMIC SPHERULES in NODULES and ASSOCIATED SEDIMENTS
- 24a- ECONOMIC POTENTIAL of MANGANESE NODULES
  - b- NODULE EXPLORATION and MINING
  - c- METALLURGICAL PROCESSING of NODULES
- 25 - ENVIRONMENTAL ASPECTS of NODULE MINING, PROCESSING, and UTILIZATION
- 26 - LEGAL ASPECTS of OCEAN-FLOOR MINING



## ABBREVIATIONS USED IN INDEX

accum(s) = accumulation(s) or accumulating  
assoc(s) = association(s) or associated  
assoc/w = associated with  
Atl = Atlantic Ocean  
avg = average  
Calif = California  
chem = chemistry or chemical  
distrib = distribution  
DSDP = Deep Sea Drilling Project  
DTA = differential thermal analysis  
E = East  
electrochem = electrochemistry or electrochemical  
Equat = Equatorial  
exped = expedition  
Fe-Mn = ferromanganese  
geochem = geochemistry or geochemical  
HIG = Hawaii Institute of Geophysics  
IDOE = International Decade of Ocean Exploration  
Ind Oc = Indian Ocean  
intl = international  
Medit = Mediterranean Sea  
micronod(s) = micronodules(s)  
MORB = mid-ocean ridge basalt  
N = North  
nod(s) = nodule(s)

Pac = Pacific Ocean

petrol = petrology or petrologic

physiochem = physiochemistry or physiochemical

radiochem = radiochemistry or radiochemical

REE = rare-earth elements

S = South

sed = sediment or sedimentary

seds = sediments

SEM = scanning electron microscope or microscopy

spectrochem = spectrochemistry or spectrochemical

stratig = stratigraphy or stratigraphic

XRD = x-ray diffraction

W = West

S E C T I O N 1

MANGANESE NODULES--GENERAL

This section includes publications with significant coverage of several aspects of manganese nodule research, as well as shorter papers with generalized titles and/or contents.

MANGANESE NODULES--GENERAL

Abbott, 1973	Intl cooperation; <u>Valdivia</u> -HIG
Andrews, <u>et al.</u> , 1972	Fe-Mn deposits; central Pacific; investigations
Andrushchenko and Skornyakova, 1970	Fe-Mn nods
Anonymous, 1959	Mn nods
Anonymous, 1969b	Mn nods and phosphorite
Arrhenius, 1963	Pelagic seds
Arrhenius, 1967	Deep-sea sedimentation
Bender, 1970	Mn nods
Blatt, <u>et al.</u> , 1972	Sedimentary Mn nods
Bonatti, <u>et al.</u> , 1965b	Mn; ocean bottom
Broughton, 1972	Mn nods
Buchanan, 1881	Mn nods; sea bottom occurrence
Calvert and Price, 1970a	Mn nods; promise and problems
Cronan, 1974	Authigenic minerals in deep-sea seds
Davin, 1972	IDOE; resource geology
Davin, 1973	IDOE; Seabed Assessment Program
Dept. of Planning and Economic Development, 1972	Mn nod deposits; Pacific
Dorr, 1972	Mn formation
Firth, 1969	Encyclopedia of marine resources
Glasby, 1970	Mn nods and assoc pelagic seds; Indian Ocean; geochem
Goodell, 1965b	Marine geology; Southern Ocean

Goodell, <u>et al.</u> , 1971	Fe-Mn deposits; Pacific-Antarctic region
Grabbe, 1972	Mn nod deposits; Pacific; assessment workshop
Greenslate, 1972	Pacific nods; Scripps data
Gumbell, 1878	Occurrence of Mn nods on ocean bottom
Heezen and Hollister, 1971	Ion by ion
Heezen, Tharp, and Ewing, 1959	Floors of the oceans
Horn, D. R., 1972a	Fe-Mn deposits; ocean floor
Horn, D. R., 1972b	Deep-sea Mn deposits; worldwide distrib and metal content
Horn, D. R., Horn, and Delach, 1972a	Fe-Mn deposits; world ocean
Hubred, 1975	Deep-sea Mn nods: review of literature
Kerl, 1970	Mn nods; ocean floor; properties, occurrence, and origin
MacDonald, G. J. F., 1967	What's in the ocean
Manheim, 1965b	Fe-Mn accums; shallow marine
Menard, 1964	Pacific; marine geology
Mero, 1960a	Minerals; ocean floor
Mero, 1962	Mn nods; ocean floor
Mero, 1965	Mineral resources; sea
Mero, 1966c	Mn nods; deep sea
Morgenstein, 1973b	Mn nods; origin and distrib; Pacific
Murray, J., 1876	Specimens; sea bottom
Murray, J. and Irvine, 1894	Mn oxides and Mn nods; marine deposits
Murray, J. and Lee, 1909	Depth and marine deposits; Pacific
Murray, J. and Renard, 1891	Mn nods; HMS <u>Challenger</u>

Okada and Shima, 1970	Mn nods
Pettersson, 1945	Fe and Mn; ocean floor
Price, 1967	Mn-Fe nods; geochem observations; different depth environments
Riley and Chester, 1971	Marine chem; introduction
Schweisfurth, 1971	Mn nods; ocean
Seabed Assessment Program, 1972	Fe-Mn deposits; ocean; research
Seabed Assessment Program, 1973	Fe-Mn deposits; ocean; research
Skornyakova and Andrushchenko, 1964	Fe-Mn nods; Pacific
Takebayashi, 1972	Japan; present activities in marine science and technology
Thomson, 1874	Nature of sea bottom, HMS <u>Challenger</u>
UNESCO, 1970	Oceanic exploration and research; programme outline
Varentsov, 1964	Mn ores; sedimentary
Varentsov, 1971	Mn nods and crusts; formation; Recent basins
Wilckens, 1972	Federal Republic of Germany; activities in marine science and technology
Xavier, 1971	Mn nods in the oceans
Zenkovitch and Skornyakova, 1961	Fe and Mn; ocean bottom

## S E C T I O N 2

### a - BIBLIOGRAPHIES

This section lists only those publications that are exclusively bibliographies. Extensive bibliographies on various aspects of manganese research can be found at the end of many publications.

### b - SYMPOSIUMS AND COLLECTIONS OF PAPERS

This section lists references that are either symposium proceedings or collected reports on nodule research.

## BIBLIOGRAPHIES

Battelle Memorial Institute,  
1971

Selected annotated bibliography:  
environmental disturbances of concern  
to marine mining

Glasby, 1972b

Bibliography; Mn nodes; marine

Glasby, 1972c

Bibliography; Mn nodes; marine; addendum

Koers, 1970

Bibliography, 1960-1970; debate on  
legal regime for exploration and  
exploitation of ocean resources

Wang and Quinterno, 1974

Bibliography on world subsea mineral  
resources (1970-1972)



SYMPOSIUMS AND COLLECTIONS OF PAPERS

Andrews, <u>et al.</u> , 1972	Fe-Mn deposits; central Pacific; investigations
Dept. of Planning and Economic Development, 1972	Mn nod deposits; Pacific
Dorr, 1972	Mn formation; report on technical sessions
Horn, 1972a	Fe-Mn deposits; ocean
International Geologic Congress, 1956	Mn deposits; symposium
Kruppa, 1973	Interocean '73, Düsseldorf
Morgenstein, 1973b	Mn nodds; origin and distrib; Pacific
Riley and Skirrow, 1965a,b	Chemical oceanography
Seabed Assessment Program, 1972	Fe-Mn deposits; ocean; research
Seabed Assessment Program, 1973	Fe-Mn deposits; ocean; research



### S E C T I O N 3

#### DATA COLLECTIONS AND EXPEDITION REPORTS

This section lists publications that are either primarily data compilations or are specifically titled as expedition reports.

DATA COLLECTIONS AND EXPEDITION REPORTS

Agassiz, 1901	<u>Albatross</u> expedition
Agassiz, 1906	<u>Albatross</u> expedition
Andrews and Meylan, 1972	<u>Kana Keoki</u> 72-Mn cruise; bottom photography
Andrews, <u>et al.</u> , 1973	HIG data banks; Mn; hydration-rind dating
Andrews, Callender, <u>et al.</u> , 1974	<u>Moana Wave</u> cruise Mn 74-01; Fe-Mn deposits on ocean floor; NE Equat Pacific
Anonymous, 1971d	<u>Akademik Kurchatov</u> ; 1968 and 1969
Beiersdorf and Bungenstock, 1973	Seismic reflection for Mn nod exploration with <u>Valdivia</u> ; NE Equat Pacific
Berritt and Rotschi, 1956	Cores from central and west Equat Pacific; chem analyses; Swedish Deep-Sea Expedition
Bezrukov, 1963	<u>Vityaz</u> 35th cruise; Indian Ocean
Bezrukov, 1969	<u>Vityaz</u> 43rd cruise; central Pacific
Bezrukov, 1971b	<u>Vityaz</u> 48th cruise; Pacific; May-Sept. 1970
Blazhchishin and Yemel'Yanov, 1969	<u>Professor Dobrynin</u> ; Baltin
Böggild, 1916	<u>Siboga</u> Expedition; ocean-bottom samples
Boström, 1970c	<u>Eltanin</u> cruise 39
Buchanan, 1876	Chem and geological work done on board HMS <u>Challenger</u>
Cruickshank, 1972b	Compilation of station positions and analyses of Mn nodules in table form
Frazer, J. Z. and Arrhenius, 1972	Fe-Mn nodules; worldwide distrib; Pacific element concentrations

Greenslate, 1972	Pacific nods; Scripps data
Greenslate, <u>et al.</u> , 1972	Chem mapping; ocean floor; computerized data bank
Heady, 1967	Marine Mn nods; collection and analysis
Hidaka, 1966	Intl Indian Ocean Expedition; Japan participation
Hinz and Schlüter, 1973	<u>Valdivia</u> cruise Manganknollen I; Equat Pacific; results of seismic reflection measurements
Holm, 1887	Oversigt over Bundskrabninger udførte paa <u>Djmphna</u> , 1882; Kara Sea concretions
Horibe, 1970	<u>Hakuho Maru</u> cruise KH-68-4; Southern Cross cruise
Horn, D. R., Horn, and Delach, 1972b	Fe-Mn deposits; North Pacific
Jacobs, <u>et al.</u> , 1970	<u>Eltanin</u> cruises 32-36, 1968
Jacobs, <u>et al.</u> , 1972	<u>Eltanin</u> cruises 42-46, 1970
Kaneshima and Yonahara, 1970	8th Japanese Antarctic Research Expedition; Fe and Mn in particulate matter; surface water
Kollwentz, 1973a,b	Exploration methods and techniques-experiences; <u>Valdivia</u>
Kuenen, 1942	<u>Snellius</u> expedition; geological results: bottom samples
Meyer, 1973a,b	<u>Valdivia</u> cruises 1972/73; NE Equat Pacific; surface sed and Mn nod facies
Meylan, <u>et al.</u> , 1975	<u>Tangaroa</u> ; Mn nod investigations; 1974; SW Pacific Basin
Murray, J., 1885	Specimens of bottom deposits collected by <u>Blake</u> , 1877-1880; report
Murray, J. and Philippi, 1908	Deutschen Tiefsee-Expedition
Murray, J. and Renard, 1891	HMS <u>Challenger</u> ; Mn nods

National Oceanographic Data Center, 1971	Listing of bottom surface sed samples with Mn described
Neeb, 1944	<u>Snellius</u> expedition, bottom samples
Nordenskiöld, 1881	Voyage of <u>Vega</u> round Asia and Europe; Kara Sea concretions
Pratt and Thompson, 1962	<u>Atlantis</u> cruises 280-281, Woods Hole
Revelle, 1944	Seventh <u>Carnegie</u> cruise; Pacific; marine bottom samples
Richter and Schlüter, 1973	<u>Valdivia</u> exploration for Mn nod; 1973; seismic reflection survey
Riedel, 1962	PROA expedition, ship-board geological report
Rossolimo, 1923	Zhurnal dragirovok i planktonnykh lovov ekspeditsii Institute 1921 goda
Schultze-Westrum, 1973a,b	Station and cruise pattern of <u>Valdivia</u> in relation to the variability of Mn nod occurrences; NE Equat Pacific
Stevenson and Stevenson, 1970	Mn nod from <u>Challenger</u> Expedition at Redpath Museum
Takeda, 1974	Investigations of deep sea mineral resources; NW Pacific
Thomson, 1874	HMS <u>Challenger</u> ; nature of sea bottom
Thoulet, 1910	Lithologic study of bottom collection from near Novaya Zemlya
Tornoda, 1968	<u>Hakuho Maru</u> cruise KH-68-3
Veber, 1908	Iz ekspeditsii <u>Ermaka</u> v 1901 godu
von der Borch and Rex, 1970	DSD5 Leg 5; amorphous Fe-oxide precipitates
von der Borch, <u>et al.</u> , 1971	DSDP Leg 8; Fe-rich sed

## S E C T I O N 4

### MARINE DISTRIBUTION AND OCCURRENCE OF NODULES AND MANGANIFEROUS SEDIMENTS

#### a - BOTTOM PHOTOGRAPHY OF NODULES

This section contains publications on deep-sea photographic studies, as well as references containing a significant number of bottom photographs of nodules.

#### b - PACIFIC OCEAN

This section includes articles on ferromanganese accumulations of the Pacific Ocean, as well as those of smaller seas adjacent to the Pacific.

#### c - ATLANTIC OCEAN

This section contains articles dealing primarily with ferromanganese accumulations of the Mid-Atlantic Ridge and Blake Plateau. Publications on the Scotia Sea are listed under Section 4e. Reports on the Gulf of Mexico and Caribbean Sea are listed in Section 4h.

#### d - INDIAN OCEAN AND RED SEA

This section lists articles on ferromanganese accumulations of the Indian Ocean and Red Sea, including continental margin occurrences.

e - ANTARCTIC OCEAN

This section contains reports on ferromanganese deposits found in the high southern latitudes of the Pacific, Indian, and Atlantic Oceans.

f - ARCTIC OCEAN

Publications listed in this section deal primarily with ferromanganese deposits found in the shallow seas bordering European Russia.

g - MEDITERRANEAN AND EUROPEAN SEAS

Publications listed in this section deal primarily with ferromanganese deposits of the Baltic Sea, the Black Sea, and the shallow Arctic Seas of European Russia.

h - GULF OF MEXICO/CARIBBEAN SEA

This section contains articles dealing with ferromanganese deposits of the Gulf of Mexico and Caribbean Sea, as well as those of some adjacent islands and coastal areas.

i - WORLDWIDE

This section contains reports that encompass ferromanganese deposits of all the major ocean basins, as well as articles with generalized titles and contents.



## BOTTOM PHOTOGRAPHY OF NODULES

Andrews and Meylan, 1972	Central Pacific; <u>Kana Keoki</u> cruise 72-Mn
Ewing and Mouzo, 1968	North Atlantic; oldest known outcrops; bottom photos
Ewing, D. Horn, <u>et al.</u> , 1971	Mn nods on ocean floor; photographs
Ewing, Sullivan, <u>et al.</u> , 1971a	Atlantic; Mn nods and crusts; surface distrib
Ewing, Sullivan, <u>et al.</u> , 1971b	Pacific; Mn nods and crusts; surface distrib
Glasby, 1973a	Carlsberg Ridge, Mn nods and lebensspuren
Goodell, 1964	Drake Passage, Scotia Sea, South Sandwich Trench; <u>Eltanin</u>
Goodell, 1965b	Southern Ocean; marine geology; <u>Eltanin</u>
Heezen and Hollister, 1971	Ion by ion
Jacobs, <u>et al.</u> , 1970	<u>Eltanin</u> cruises 32-36
Jacobs, <u>et al.</u> , 1972	<u>Eltanin</u> cruises 37-39
Koegler, 1972	Deep-sea Mn nods; surface concentrations
Laughton, 1967	Carlsberg Ridge; underwater photography
Menard and Shipek, 1958	Pacific; Mn nods; surface concentrations
Moore, J. G. and Fiske, 1969	Hawaii; volcanic substructure; dredge samples and photos
Patterson, 1972	Mn deposits in deep water; inspection of
Pratt, 1967	Seamounts; photography of
Shipek, 1970	East Pacific; deep-sea floor; photos

PACIFIC OCEAN

- Amos, et al., 1973b E Equat Pac; environmental oceanography; deep-sea mining
- Andrews, 1971 N Pac; fracture zones; transcurrent faulting
- Andrews, 1972 Hawaii; distrib of Mn nod
- Andrews and Meylan, 1972 Central Pac; Kana Keoki cruise 72-Mn; bottom photography
- Andrews and Meylan, 1973 Equat Pac; bathymetry and Mn accretion
- Andrews, Callender, et al., 1974 NE Equat Pac; Fe-Mn deposits on ocean floor; Moana Wave cruise Mn 74-01
- Andrushchenko and Skornyakova, 1967 Pac; Mn nod; composition, structure and features of formation
- Andrushchenko and Skornyakova, 1969 S Pac; Fe-Mn concretions; texture and mineral composition
- Anonymous, 1971a Hawaii; Mn deposit
- Anonymous, 1971b Hawaii; Mn off Kauai
- Anonymous, 1971c Kauai Channel; Mn nod
- Anonymous, 1971g Pac; Mn nod; deep-sea
- Anonymous, 1971h Pac (and Ind Oc); phosphorite and Mn nod distrib
- Anonymous, 1971i Mexico, west coast; dredged basalt
- Anonymous, 1971j Hawaii; Mn deposit
- Beiersdorf and Bungenstock, 1973 NE Equat Pac; seismic reflection for Mn nod exploration with Valdivia
- Bender, Broecker, et al., 1970 E Pac Rise; Mn and related elements; accum rate in sed
- Bender, Broecker, et al., 1971 E Pac Rise; geochem of cores
- Bezrukov, 1960 NW Pac; sedimentation

Bezrukov, 1969	Central Pac; 43rd cruise of <u>Vityaz</u>
Bezrukov, 1971a	Pac; geologic structure and mineral resources
Bezrukov, 1971b	Pac; 48th cruise of <u>Vityaz</u>
Bezrukov, 1972	S Pac; sedimentation
Bischoff and Sayles, 1972	Bauer Depression, E Pac Rise; Recent marine sed; pore fluid and mineralogical studies
Bonatti, 1966	Pac; volcanic minerals in pelagic sed
Bonatti, 1967	S Pac; mechanism of deep-sea volcanism
Bonatti and Joensuu, 1966	S Pac; Fe deposit; deep-sea
Bonatti and Joensuu, 1967	S Pac; deep-sea Fe deposits
Boström, 1970e	E Pac Rise; origin of Fe-rich sed
Boström and Fisher, 1969	E Pac; distrib of mercury in sed
Boström and Peterson, 1966	E Pac Rise; precipitates from hydrothermal exhalations
Boström and Peterson, 1967	E Pac Rise; hydrothermal exhalations and possible ore-forming processes
Boström and Peterson, 1969	E Pac Rise; Al-poor Fe-Mn sed; origin
Boström, Peterson, <u>et al.</u> , 1968	E Pac (and Ind Oc); origin of anomalous sed in areas of high-heat flow
Bramlette, <u>et al.</u> , 1959	Eniwetok; anomalous sed deposition
Burk, 1973	SW Pac; mineral resources of the oceans
Caldwell, 1971	Deep Sea Ventures readying its attack on Pacific nods
Chaynikov, 1969	Pac; source of Mn in sed
Cherdyntsev, <u>et al.</u> , 1971	Pac; Mn nods; origin based on radioisotope data
Conolly, 1969	W Tasman Sea; sea floor

Cook, 1971	Equat Pac; Fe and Mn-rich seds over basalt basement
Cronan and Garrett, 1973a	E Pac; element partition in basal metalliferous seds
Cronan and Garrett, 1973b	Pac; distrib of elements in metalliferous seds; DSDP
Cronan and Tooms, 1967a	Pac; Mn nods in sed
Cronan and Tooms, 1969	Pac (and Ind Oc); geochem of Mn and pelagic deposits
Cronan, Van Andel, <u>et al.</u> , 1972	E Equat Pac; Fe-rich basal sed
Dasch, Diamond, and Heath, 1971	E Pac Rise; metalliferous sed; isotopic analysis
Dasch, Heath, and Dymond, 1971	E Pac Rise; isotopic analysis of metalliferous sed
Dietz, 1955	NE Pac; Mn deposits
Dymond, <u>et al.</u> , 1972	E Pac Rise and DSDP; metalliferous seds; chem, isotopic and mineralogical study
Dymond, <u>et al.</u> , 1973	E Pac Rise; metalliferous seds; elemental and isotopic geochem
Dymond, <u>et al.</u> , 1974	Pac; origin of metalliferous seds
Ehrlich, H., <u>et al.</u> , 1972	Atl and Pac; distrib of microbes in Mn nods
Eklund, 1974	Bauer Deep; metalliferous sed components; microprobe study
Ewing, Sokolsky, and Aitken, 1968	N Pac; distrib of Mn nods
Ewing, Sullivan, <u>et al.</u> , 1971b	Pac; distrib of Mn nods and crusts; bottom photos
Fein and Morgenstein, 1972, 1973	Hawaii; microprobe analysis of Mn crusts
Ferguson and Lambert, 1972	New Britain; volcanic exhalations and metal enrichments

Fewkes, <u>et al.</u> , 1974	Pac; Cu-Ni rich segregations in Mn nodds
Firth, 1969	Pac (and worldwide); marine resources
Fisher, D. E. and Boström, 1969	E Pac Rise; uranium-rich seds
Fomina, 1962	SW Pac; oxidative-reductive processes in sed
Foster, 1972	Baja California, growth of Mn nodds
Frazer, J. Z. and Arrhenius, 1972	Pac (and worldwide); Fe-Mn nod distrib and composition
Friedrich, <u>et al.</u> , 1973	NE Equat Pac; deep sea Mn nodds; geochem investigation on board <u>Valdivia</u> ; application of EDX-technique
Friedrich, <u>et al.</u> , 1969	Pac; Mn-concretions; micro-studies
Glagoleva, 1971	NW Pac; chem of Fe-Mn nodds
Glagoleva, 1972	NW Pac; Fe-Mn concretions in sedds; characteristics of changes in chem composition
Glasby, 1972a	SW Pac; Mn deposits
Glasby, 1974a	S Pac; exploitation of Mn nodds
Glasby, Meylan, and Bäckér, 1974	SW Pac Basin; distrib and morphology of Mn nodds
Glasby, Bäckér, <u>et al.</u> , 1974	SW Pac near New Zealand; extensive Mn nod province discovered
Goldberg and Arrhenius, 1958	Pac; chem of pelagic sedds
Goldberg and Koide, 1958	Pac; ionium-thorium chronology; deep-sea sedds
Goncharov, <u>et al.</u> , 1973	Pac; investigation of Fe-Mn concretions by nuclear magnetic resonance
Grabbe, 1972	Pac; Mn nod deposits
Greenslate, 1972	Pac; Scripps data; nodds

Greenslate, <u>et al.</u> , 1973	Pac; origin and deposition of selected transition elements in seabed
Grill, <u>et al.</u> , 1968a	British Columbia; fjord; todorokite in Mn nod
Grill, <u>et al.</u> , 1968b	British Columbia, Jervis Inlet; Mn nod
Hamilton, 1956	Mid-Pac; sunken islands
Hamilton and Rex, 1959	Sylvania Guyot; lower Eocene phosphatized Globigerina ooze
Hartmann, <u>et al.</u> , 1973	Pac seds; geochem and soil-mechanical investigations
Heezen, Glass, and Menard, 1966a, b	Manihiki Plateau
Herzer, 1970	Bowie Seamount; geology of
Herzer, 1971	Bowie Seamount
Hinz and Schlüter, 1973	Equat Pac; <u>Valdivia</u> cruise Manganknollen I; results of seismic reflection measurements
Hollister, <u>et al.</u> , 1974	Samoa Passage; current-controlled abyssal sedimentation
Holmes, Goodell, and Osmond, 1967	S Pac; geochronology
Holmes, Osmond, and Goodell, 1966	S Pac (Antarctic); geochronology of <u>Eltanin</u> cores
Horn, D. R., 1972b	Pac (and worldwide); distrib and metal content of Mn deposits
Horn, D. R., Horn, and Delach, 1972b	N Pac; Fe-Mn deposits
Horn, D. R., Horn, and Delach, 1973a, b	NE Equat Pac; Cu and Ni content of ocean Fe-Mn deposits; relation to properties of substrate
Horn, D. R., Horn, and Delach, 1974	Equat Pac; Ni- and Cu-rich nods
Horn, D. R., Ewing, <u>et al.</u> , 1971b	Pac; distrib of Mn nods (based on cores)

Horn, D. R., Ewing, <u>et al.</u> , 1972b	S Pac; distrib of Mn nods and crusts (based on cores and dredges)
Horn, D. R., Ewing, <u>et al.</u> , 1972c	N Pac; distrib of Mn nods and crusts (based on cores and dredges)
Hryniewicz, <u>et al.</u> , 1970a, b	Pac; Fe-Mn nods; Mössbauer effect
Hryniewicz, <u>et al.</u> , 1972b	Pac; Mössbauer effect analysis of Fe-Mn nods
Hubred, 1970b, c	Pac; abyssal hill; Mn nods; morphology and transition metals
Kaufman and Siapno, 1972	Pac; Mn nod deposits
Koster, 1966	Pac-Antarctic Ridge; sed and sed history
Lalou, Delibrias, <u>et al.</u> , 1973	Pac; C <sup>14</sup> at center of two Mn nods; C <sup>14</sup> and Th <sup>230</sup> ages of the nods
Landmesser and Morgenstein, 1973	Hawaiian Archipelago; Mn deposits; survey and mapping
Lonsdale, Normark, and Newman, 1972	Horizon Guyot; sedimentation and erosion
Lonsdale, Southard, and Hollister, 1971	N Pac; erosion of red clay; flume study
Lueschow and Kraft, 1973	Pac; Mn nods; nondispersive x-ray spectrometry
Macdonald and Murray, 1973	British Columbia fiord (Jervis Inlet); sedimentation and Mn concretions
Mark, 1972	Hawaii; nods
Menard, 1960	E Pac; consolidated slabs on ocean floor
Menard, 1964	Pac; geology
Menard and Shipek, 1958	Pac; surface concentrations of Mn nods
Meyer, 1973a, b	NE Equat Pac; surface sed and Mn nod facies; <u>Valdivia</u> cruises 1972/73
Meylan, <u>et al.</u> , 1975	SW Pac Basin; <u>Tangaroa</u> Mn nod investigations

Moore, J. G. and Fiske, 1969	Hawaii, volcanic substructure (from dredge and photos)
Moore, T. C., 1970	Central Equat Pac; sed and stratig of abyssal hills
Moore, T. C. and Heath, 1966	Central Pac; Mn nodds; topography and thickness of sed
Morgenstein, 1967	Society Ridge; scoriaceous deep-sea sed
Morgenstein, 1969	Pac (and Atl); palagonite in deep-sea sed
Morgenstein, 1972a	Hawaii, Waho Shelf; Mn accretion at sediment-water interface
Morgenstein, 1972c	Hawaii, Waho Shelf; sed diagenesis and rates of Mn accretion
Morgenstein, 1973a	Hawaii; sed diagenesis and rates of Mn accretion
Morgenstein, 1973b	Pac; origin and distrib of Mn nodds and prospects for exploration
Morgenstein and Andrews, 1971	Hawaii; Mn resources
Mudie and Grow, 1972	Pac; topography of abyssal hills in Mn nod province
Murata and Erd, 1964	Mohole Guadalupe Site; composition of sedds
Murdmaa, <u>et al.</u> , 1972	Pac; volcanogenous clastic rocks
Murray, J. and Lee, 1909	Pac; depth and marine deposits
Nayudu, 1965a	Mendocino Fracture Zone; submarine volcanics and sedds; petrology
Nayudu, 1965b	Pac (and Atl); palagonite and Mn-crusts; petrol and chem studies
Niino, 1955	Japan, Izu Islands; Mn nod and <u>Perotrochus</u> ; dredged
Niino, 1959	Japan, Mn nodds



Nikolayev and Yefimova, 1963	Pac (and Ind Oc); age of Fe-Mn concretions
Nohara, 1972	Pac; Mn minerals in Fe-Mn nods dredged from seamounts
Okada and Shima, 1969	Sea-floor Mn nod; comparison with nod from core
Park, 1972	Pac Basin; Fe ore deposits
Payne and Conolly, 1972	Tasman Sea; Pleistocene Mn pavement production; Mn origin
Piper, 1971	E Pac Rise; distrib of trace elements in sed
Piper, 1972	Pac; REE in Mn nods
Piper, 1973c	E Pac Rise; origin of metalliferous sed
Price and Calvert, 1970	Pac; Fe-Mn nods; composition relation to sed accum rates
Raab, 1972	Pac; Mn nods; physical and chem features; nod genesis
Revelle, 1944	Pac; marine bottom samples collected by seventh <u>Carnegie</u> cruise
Revelle, <u>et al.</u> , 1955	Pac; distrib and chem composition of sed
Rex, 1967	Marshall Islands, Sylvania Guyot; authigenic silicates
Riedel, 1962	PROA expedition; ship-board geological report
Riley and Sinhaseni, 1958	Pac; chem composition of Mn nods
Rozanov, <u>et al.</u> , 1972	NW Pac; forms of Fe and Mn in sed
Rydell, <u>et al.</u> , 1974	E Pac Rise; postdepositional injections of uranium-rich solutions into sed
Sayles and Bischoff, 1973	Equat E Pac; Fe-Mn sed
Schatz, 1971	Pac; Mn nods, sampling and occurrence

Schultze-Westrum, 1973a, b	NE Equat Pac; station and cruise pattern of <u>Valdivia</u> ; relation to variability of Mn nod occurrence
Shima and Okada, 1968	Mid-Pac; Mn nods from deep-sea core
Shipek, 1960	E Pac; photographic study of deep-sea floor
Skornyakova, 1960	NE Pac; Mn concretions in seds
Skornyakova, 1965	Pac; Fe and Mn in seds
Skornyakova, 1966	Pac; Fe and Mn in seds
Skornyakova and Andrushchenko, 1964	Pac; Fe-Mn nods
Skornyakova and Andrushchenko, 1968	Central S Pac; Fe-Mn nods
Skornyakova and Andrushchenko, 1971	Pac; morphology and structure of Fe-Mn nods
Skornyakova and Andrushchenko, 1974	Pac; Fe-Mn concretions
Skornyakova and Petelin, 1967	S Pac; seds
Skornyakova and Zenkevich, 1961	Pac; distrib of Fe-Mn nods in top layers of deposits
Skornyakova, <u>et al.</u> , 1962	Pac; chem composition of Fe-Mn nods
Somayajulu, <u>et al.</u> , 1971	Equat Pac; Mn nods and assoc seds; rates of accum
Sorem and Foster, 1969	West of Baja Calif; Mn nods growth history
Strakov and Nesterova, 1968	Okhotsk; volcanic effect on geochem of marine deposits
Summerhayes, 1967a	SW Pac; Mn nods
Summerhayes, 1967b	New Zealand; economic mineral deposition
Takeda, 1974	NW Pac; investigations of deep sea mineral resources

Tinsley, 1973	Pac; search for commercial nods
Volkov and Fomina, 1973	Pac; new data on geochem of REE in seds
Volkov, Rosanov, and Sokolov, 1971	NE Pac; oxidation and reduction processes in seds
von der Borch and Rex, 1970	NE Pac; DSDP Leg 5; amorphous Fe oxide precipitates in seds
von der Borch, <u>et al.</u> , 1971	E Equat Pac; DSDP Leg 8; Fe-rich seds
Weber, 1973	Pac; exploration for Mn nods

ATLANTIC OCEAN

- Addy, et al., 1974  
Atl, near Bermuda; abyssal hills, Mn  
nods in sed column
- Anonymous, 1971f  
Atlantic geotraverse; Mn encrustation
- Aumento, 1969  
Mid-Atl Ridge - 45°N; fission track  
and Fe-Mn chronology
- Aumento and Loncarevic, 1969  
Mid-Atl Ridge - 45°N; Bald Mountain
- Aumento, Lawrence, and Plant,  
1968  
San Pablo Seamount; Fe-Mn pavement
- Aumento, Loncarevic, and Ross,  
1971  
Mid-Atl Ridge - 45°N; geology of
- Bartlett and Greggs, 1970b  
San Pablo Seamount; carbonates
- Böstrom, 1970b  
S Atl; geochem evidence for sea-floor  
spreading
- Böstrom, Joensuu, Valdes, and  
Riera, 1972  
S Atl; geochem history of sed
- Brundage, 1972  
Blake Plateau; Mn pavement distrib  
patterns
- Chester, et al., 1973  
SW region of N Atl; similarities  
between Mn, Ni, Co contents of deep-  
sea clays and Mn nod
- Cronan, 1972a  
Mid-Atl Ridge - 45°N; Al, As, Hg, and  
Mn in ferruginous sed
- Cronan, 1972c  
Atl; composition of Mn nod
- Ehrlich, H., et al., 1972  
Atl and Pac; distrib of microbes in  
Mn nod
- Ewing and Mouzo, 1968  
N Atl; photos in area of oldest known  
outcrops
- Ewing, Shipley, and Connary,  
1973  
N Atl; survey of Mn nod region
- Ewing, Sullivan, et al., 1971a  
Atl; surface distrib of Mn nod and  
crusts based on bottom photos

Feden, 1966	Caryn Seamount; volcanic rock
Fox, P. J. and Heezen, 1965	Mid-Atl Ridge; sands of
Gorshkova, 1960	Norwegian Sea; seds of
Grice and Hancock, 1972	San Pablo Seamount; processing of Mn pavement
Hawkins, 1968, 1969	Blake Plateau; visual observations of Mn deposits
Hayes and Ewing, 1970	N Brazil Ridge and adjacent continental margin
Horn, D. R., Ewing, Horn, and Delach, 1971a	Atl; surface distrib of Mn nods and crusts (based on deep sea cores)
Horn, D. R., Ewing, Horn, and Delach, 1972d	N Atl; surface distrib of Mn nods and crusts (based on core and dredges)
Horn, D. R., Ewing, Horn, and Delach, 1972e	S Atl; surface distrib of Mn nods and crusts (based on core and dredges)
Kharin, 1973	Flank of Mid-Atl Ridge; Fe-Mn nods
Krause and Schilling, 1969	Reykjanes Ridge; dredged basalt
Manheim, 1972	Blake Plateau; composition and origin of Mn-Fe nods and pavements
Manheim and Pratt, 1968	Blake Plateau; geochem of Mn-phosphorite deposits
Manheim, Pratt, and McFarlin, 1967	Blake Plateau; geochem of Mn and phosphate deposits
Mathews, 1961	N Atl; lavas from abyssal hill
Mathews, 1962	NE Atl; altered lavas
Mathews, 1971	NE Atl, Swallow Bank; altered lavas
McGregor, <u>et al.</u> , 1974	Crest of Mid-Atl Ridge at 26°N; hydrothermal Mn deposit
Medcof, 1963	Georges Bank; puzzling clay tubes from sea bottom
Melson, <u>et al.</u> , 1968	Mid-Atl Ridge - 22°N; volcanism and metamorphism

Morgenstein, 1969	Atl (and Pac); palagonite in deep sea seds
Murray, J., 1885	Western N Atl; report on specimens of bottom deposits collected by <u>Blake</u> , 1877-1880
Murray, J. and Philippi, 1908	Atl nods
Nayudu, 1965b	Atl (and Pac); palagonite and Mn- crusts; petrol and chem studies
Phillips, <u>et al.</u> , 1969	Mid-Atl Ridge, near 43°N
Pratt, 1971	Blake Plateau; lithology of dredged rocks
Pratt and McFarlin, 1966	Blake Plateau; Mn pavement
Pratt and Manheim, 1967	Blake Plateau; relation of Mn to phosphorite concretions
Schwarz, 1968	Mid-Atl Ridge; thermomagnetic properties of banded Mn sed
Scott, M. R., Scott, Nalwalk, <u>et al.</u> , 1973	Mid-Atl Ridge; hydrothermal Mn in median valley
Scott, M. R., Scott, Rona, <u>et al.</u> , 1974	Median valley of Mid-Atl Ridge; rapidly accum Mn deposit
Scott, M. R., Scott, Morse, <u>et al.</u> , 1974	TAG hydrothermal field; transition metals in adjacent seds
Scott, R. B., Scott, Swanson, <u>et al.</u> , 1974	TAG hydrothermal field
Scott, R. B., Rona, <u>et al.</u> , 1972	Atlantis Fracture Zone; Mn crusts
Shih, <u>et al.</u> , 1974	NW Atl; spacial distrib of Mn nods
Smith, R. E., <u>et al.</u> , 1968a	Nares Abyssal Plain; Mn nods; geochem
Smith, R. E., <u>et al.</u> , 1968b	Nares Abyssal Plain; Fe-Mn nods; geochem and mineralogy
Stetson, <u>et al.</u> , 1962	Coral banks occurring in deep water on Blake Plateau

Stetson, <u>et al.</u> , 1969	Blake Plateau; surface and subsurface morphology of two small areas
Verrill, 1884	Off southern coast of New England; notice of the remarkable marine fauna occupying outer banks
Vikhrenko, 1967	Atl; distrib of Fe and Mn in surface layers
Wedepohl, 1960	Atl; deep-sea samples; trace analysis

INDIAN OCEAN AND RED SEA

- Anonymous, 1971h Ind Oc (and Pac); phosphorite and Mn nod distrib
- Baturin, et al., 1969 Red Sea; composition and origin of Fe-ore seds and hot brines
- Bezrukov, 1962 Ind Oc; distrib of Fe-Mn concretions
- Bezrukov, 1963 Ind Oc; 35th cruise of Vityaz
- Bezrukov and Andrushchenko, 1972 Ind Oc; Fe-Mn nods
- Bezrukov and Andrushchenko, 1974 Ind Oc; geochem of Fe-Mn nods
- Böggild, 1916 Timor and Ceram Seas; ocean-bottom samples; Siboga expedition
- Boström, Peterson, et al., 1968 Ind Oc (and E Pac); origin of anomalous seds in areas of high-heat flow
- Cann, 1970 Gulf of Aden; dredged basalts; petrol
- Cann and Vine, 1966 Carlsberg Ridge; petrol and magnetic survey
- Cronan and Tooms, 1967b NW Ind Oc; geochem of Mn nods
- Cronan and Tooms, 1968 NW Ind Oc; Mn nods; microscopic and electron probe investigations
- Cronan and Tooms, 1969 Ind Oc; geochem of Mn nods and assoc pelagic deposits
- Gieskes, et al., 1974 Ind Oc; geochem evidence for extensive diagenesis in DSDP Hole 245
- Glasby, 1970, 1971 Ind Oc; geochem of Mn nods and assoc pelagic seds
- Glasby, 1972e NW Ind Oc; geochem of Mn nods
- Glasby, 1972h NW Ind Oc; pelagic seds; trace metal geochem; influence of manganiferous fragments



Glasby, 1972j	Ind Oc (and Antarctic); nods
Glasby, 1973b	Carlsberg Ridge; photos; Mn nod distrib and lebensspuren
Glasby, 1973c	North of Indian-Antarctic Ridge; Mn deposits of variable composition
Glasby and Hodgson, 1971	NW Ind Oc; distrib of organic pigments in Mn nods
Glasby, Tooms, and Cann, 1971	Gulf of Aden; geochem of Mn encrustations
Glasby, Tooms, and Howarth, 1974	NW Ind Oc; Mn concretions; geochem
Hidaka, 1966	Ind Oc; report on Intl Indian Ocean Expedition
Isayeva, 1967	Ind Oc; chem of Fe-Mn concretions
Jones, E. J., 1887	Off Colombo; nodular stones (from trawling)
Kalienko, <u>et al.</u> , 1962	Ind Oc; bacteriogenic Fe-Mn concretions
Kennett and Watkins, 1975	SE Ind Oc; deep-sea erosion and Mn nod development
Laughton, 1967	Carlsberg Ridge; photography
Lisitsin, 1964	Raspredelenie i khimicheskii sostav vsvesi v vodskh Indiiskogo okeana
Manheim, Hathaway, <u>et al.</u> , 1966	Red Sea; geochem of Recent Fe deposits
Mathews, Vine, and Cann, 1965	Carlsberg Ridge; geology of
Miller, <u>et al.</u> , 1966	Red Sea; hot brines and iron deposits; DSDP
Neeb, 1944	Bottom samples; <u>Snellius</u> expedition
Nikolayev and Yefimova, 1963	Ind Oc; age of Fe-Mn concretions
Pachadzhyanov, <u>et al.</u> , 1963	Ind Oc; geochem of Mn nods
Scott, M. R., Osmond, and Cochran, 1972a,b	S Ind Basin; sedimentation rates and chem

Topping, 1969	N Ind Oc (and Arabian Sea); Mn, Co, Cu, Fe, and Zn concretions
Venkatarathnam and Nehru, 1973	SW Ind Oc; Mn nods
Wiseman, 1937	Carlsberg Ridge; geology and mineralogy of basalts

ANTARCTIC OCEAN

Boström, 1970c	<u>Eltanin</u> cruise 39
Fewkes, 1972	Drake Passage; conglomerate Mn nods
Glasby, 1972j	Antarctic (and Ind Oc); nods
Glasby, 1973b	North of Indian-Antarctic Ridge; Mn deposits of variable composition
Goodell, 1964	Drake Passage, Scotia Sea and South Sandwich Trench; marine geology
Goodell, 1965a	Scotia Sea and Ridge; sedimentary geology and its bearing on the Pleistocene
Goodell, 1965b	Southern Ocean; marine geology
Goodell, 1968a	Southern Ocean; Fe-Mn deposits
Goodell, 1968b	Southern Ocean; Fe-Mn concretions; elemental distrib
Goodell, 1969	Southern Oceans; marine geology
Goodell and Osmond, 1966	S Pac; marine geological investigations
Goodell, <u>et al.</u> , 1971	S Pac, Drake Passage and Scotia Sea; Fe-Mn deposits
Grant, 1967	Southern Oceans; Mn concretions; chem, mineralogy, distrib, and physical aspects
Grant, 1968	Southern Ocean; Fe-Mn concretions; morphology and composition; environmental controls
Heezen and Hollister, 1966	Bellingshausen Sea floor
Heezen and Hollister, 1967	Bellingshausen Sea; physiography and bottom currents
Hollister and Heezen, 1967	Bellingshausen Sea; floor of
Holmes, Goodell, and Osmond, 1967	S Pac; geochronological investigations

Holmes, Osmond, and Goodell, 1966	S Pac; geochronology of <u>Eltanin</u> cores
Margolis, 1973	Tasman Sea; Mn deposits; DSDP Leg 29
Meylan, 1968a	Southern Ocean; Fe-Mn concretions; factors governing mineralogy
Meylan, 1968b	Southern Ocean; mineralogy and geochem of Mn nods
Meylan and Goodell, 1968	Southern Ocean; Mn nods; mineralogy
Nayudu, 1973	Subantarctic Pac; geochem of deep sea Mn nods
Ostwald and Frazer, 1973	Southern Ocean; deep sea Mn nods; chem and mineralogical investigations
Paster, 1968	S Pac-Antarctic Ocean; petrologic variations within submarine basalt pillows
Paster, 1971	S Pac; petrol of submarine basalt pillows
Schornick, 1972	Southern Ocean; U and Th isotope geochem in Fe-Mn concretions
Summerhayes, 1969	Subantarctic New Zealand; marine geology of sea floor
Watkins and Kennett, 1971	Antarctic; bottom water velocity change; Late Cenozoic
Watkins and Kennett, 1972	Antarctic; regional sedimentary disconformities; Upper Cenozoic
Watkins and Self, 1971	Scotia Sea; <u>Eltanin</u> dredged rocks
Wright and Williams, 1974	Antarctica; mineral resources

## ARCTIC OCEAN

- Belov, et al., 1966 Arctic distrib of Fe, Mn carbonates and organic material in sed
- Boström, 1970a Arctic; origin of Mn-rich layers in sed
- Brujevicz, 1938 Barents and Kara Seas; oxidation-reduction potential and pH of sed
- Butkevich, 1928a,b Obrazovanie morskikh zhelezo-margantsovykh otlozhenie i uchastvuyushchie v nem mikroorganizmy
- Deryugin, 1928 White Sea; shallow marine concretions
- Gorshkova, 1931 Barents and White Seas; chem and mineralogy of sed
- Gorshkova, 1957 Kara Sea; sed
- Gorshkova, 1966 Northern Seas; Mn in sed
- Gorshkova, 1967 Northern Seas; Mn in bottom sed
- Herman, et al., 1971 Arctic; Late Cenozoic paleo-temperatures; Fe-Mn oxides in sed cores
- Holmes, M. L. and Creager, 1968 Laptev Sea continental shelf, USSR; Holocene history
- Klenova, 1936 Barents Shelf; shallow marine concretions
- Klenova, 1938 Kara Shelf; shallow marine concretions; coloring of deposits
- Klenova and Pakhomova, 1940 Barents Shelf; Mn in sed
- Kurbatov and Ermolaev, 1937 K voprosu o radioaktivnosti i khimicheskoy sostave gruntov Karskogo Morya
- Li, Bischoff, and Mathieu, 1969 Arctic Basin; Mn in sediments
- Lindström, 1884 Analyser of bergarter och bottenprof från Ishafvet, Asiens nordkust och Japan

Neveskiy and Scherbakov, 1969	White Sea; Fe accum and distrib in seds
Pakhomova, 1948	Northern Russian seas; Mn in seds
Rossolimo, 1923	Zhurnal dragirovok i planktonnykh lovov ekspeditsii Institute 1921 goda
Samoilov and Gorshkova, 1924	Barents and Kara Seas; seds
Senov, 1937	K metodike issledovaniya kondretsii Karskogo Morya
Thoulet, 1910	Lithologic study of bottom collection from near Novaya Zemlya
Turner and Harriss, 1970	Kara Sea; cores; distrib of non- detrital Fe and Mn

## MEDITERRANEAN AND EUROPEAN SEAS

- Aleksiev, 1964 Black Sea: a basin of Mn-ore formation
- Blazhchishin and Yemel'Yanov, 1969 Baltic; geology; cruise of Professor Dobrynin
- Brewer, 1972 Black Sea; particulate Mn
- Brujevicz, 1938 Barents and Kara Seas; oxidation-reduction potential and pH of seds
- Buckley, et al., 1974 NE Medit; Fe and Mn encrustations; Recent seds
- Butkevich, 1928a,b Obrazovanie morskikh zhelezo-margantsovykh otlozhenie i uchastvuyushchie v nem mikroorganizmy
- Demel and Mankowski, 1951 Quantitative studies of benthic fauna; southern Baltic
- Demel and Mulicki, 1954 Quantitative studies of biological efficiency; floor of southern Baltic
- Deryugin, 1928 White Sea; shallow marine concretions
- Fomina and Volkov, 1969 Black Sea; REE in Fe-Mn concretions
- Georgescu and Lupan, 1971 Black Sea; contributions to study of Fe-Mn concretions
- Georgescu and Nistor, 1970 Black Sea; Mössbauer study of Fe chemical bond in Fe-Mn concretions
- Georgescu, et al., 1973 Black Sea; Fe-Mn nodds; study by Mössbauer spectroscopy
- Gorshkova, 1931 Barents and White Seas; chem and mineralogy of seds
- Gorshkova, 1957 Kara Sea; seds
- Gorshkova, 1961 Osadki Ryzhskogo zaliva
- Grewingk, 1881 Gulf of Finland concretions; submarine erosion of East Baltic dolomite

Gripenberg, 1934	N Baltic; seds
Hartman, 1964	Baltic Sea; geochem of Fe and Mn
Hessle, 1923	Undersökningar rörande botten och bottenfauna i farvattnen vid Gotland och Öland
Holm, 1887	Kara Sea concretions; oversight over Bundskrabninger udforte paa <u>Dijmphna</u> , 1882
Holmes, M. L. and Creager, 1968	Laptev Sea continental shelf, USSR; Holocene history
Klenova, 1936	Barents shelf; shallow marine concretions
Kurbatov, L. M., 1935, 1937	USSR seas (and lakes); Fe-Mn formations; radioactivity
Kurbatov and Ermolaev, 1937	K voprosu o radioaktivnosti i khimicheskoy sostave gruntov Karskogo Morya
Lebedintsev, 1910	Gidrologicheskaya i gidrokhimicheskaya issledovaniya vostochnoi chasti Baltiskago Morya
Lindström, 1884	Analysen af bergarter och bottenprof från Ishafvet, Asiens nordkust och Japan
Manheim, 1961	Baltic; geochem profile
Manheim, 1965a	Baltic Sea; Recent Mn deposits
Manheim, 1965b	Shallow marine Fe-Mn accums
Murray, J., 1900	Black Sea; deposits
Neveskiy and Scherbakov, 1969	White Sea; Fe accum and distrib in seds
Nordenskiöld, 1881	Kara Sea concretions; voyage of <u>Vega</u> round Asia and Europe
Puchel, <u>et al.</u> , 1973	Off Thera, Greece; Recent marine Fe-ores: geochem, genesis, mineralogy; bacterial genesis of Fe hydroxide seds



Puntas, <u>et al.</u> , 1968	Gulf of Riga; Fe-Mn nods in seds
Rossolimo, 1923	Zhurnal dragirovok i planktonnykh lovov ekspeditsii Institute 1921 goda
Samoilov and Gorshkova, 1924	Barents and Kara Seas; seds
Schurin, 1965	Baltic; Mn effect on distrib of bottom invertebrates
Senov, 1937	K metodike issledovaniya konkretnoi Karskogo Morya
Sevast'yanov, 1967	Black Sea; Fe-Mn concretion formation; redistrib of arsenic
Sevast'yanov and Volkov, 1966	Black Sea; chem of Fe-Mn concretions
Sevast'yanov and Volkov, 1967	Black Sea; chem elements in seds
Shterenberg, 1971	Gulf of Riga; formation of Fe-Mn nods
Skopintsev and Popova, 1963	Black Sea; Mn accum in hydrogen- sulfide waters
Tornquist, 1910	Baltic Sea; detritus dredged from floor of
Turner and Harriss, 1970	Kara Sea; cores; distrib of non- detrital Fe and Mn
Varentsov, 1973	Shelf regions of recent seas; geochem aspects of formation of Fe-Mn ores
Varentsov and Blazhtchishin, 1970	Baltic Sea floor; formation of Fe-Mn nods and crust-like products
Veber, 1908	Iz ekspeditsii <u>Ermaka</u> v 1901 godu
Veltheim, 1962	Bothnia Sea; Pre-Quaternary geology of bottom
Volkov and Sevastianov, 1968	Black Sea; diagenesis of seds; redistrib of elements
Winterhalter, 1966	Gulf of Bothnia, Gulf of Finland; Fe-Mn concretions

Winterhalter and Siivola, 1967

Gulf of Bothnia, N Baltic; distrib of  
Fe, Mn, and P in concretions

Zsolnay, 1971

Baltic basin; diagenesis; organic and  
inorganic compounds

GULF OF MEXICO/CARIBBEAN SEA

Bonatti, 1971	Caribbean; Mn in sed cores
Fischer and Garrison, 1967	Fe-Mn pancakes in Cenozoic limestones dredged off Barbados
Gibson and Schlee, 1967	Bahamas; seds and fossiliferous rocks
Hurley, 1966	West Indies; geological studies
Jukes-Browne and Harrison, 1892	Barbados; geology of
Wangersky and Hutchinson, 1958	Caribbean; Mn deposits and deep water movements
Watson and Angino, 1969	Gulf of Mexico; Fe-rich layers in seds

## WORLDWIDE

Anonymous, 1966	Mn nods cover sea floor
Arrhenius, 1963	Pelagic seds
Bonatti, 1965b	Mn; ocean bottom
Buchanan, 1881	Mn nods; occurrence on sea bottom
Firth, 1969	Marine resources
Gaskell, 1965	Minerals under the sea
Heezen and Hollister, 1971	Ion by ion
Heezen, Tharp, and Ewing, 1959	Floors of the ocean
Horn, D. R., 1972b	Mn deposits; worldwide distrib and metal contents
Horn, D. R., Horn, and Delach, 1972a	Fe-Mn deposits; worldwide distrib
Horn, D. R., Ewing, Horn, and and Delach, 1972a	Mn nods; worldwide distrib
Kerl, 1970	Mn nods; ocean floor
Manheim, 1965b	Mn-Fe accums; shallow marine
Mero, 1960a	Minerals; ocean floor
Mero, 1962	Mn nods; ocean floor
Mero, 1965	Mineral resources of the sea
Murray, J. and Irvine, 1894	Mn oxides and Mn nods; marine deposits
Murray, J. and Renard, 1891	Mn nods; <u>HMS Challenger</u>
Patterson, 1972	Mn deposits; deep water
Schweisfurth, 1971	Mn nods; ocean
Smith, J. D. and Burton, 1970	Tin; worldwide occurrence and distrib
Strakhov, 1966	Ocean basins; Mn accum

Thomson, 1874

Nature of sea bottom; HMS Challenger

Zenkevitch and Skornyakova, 1961

Fe and Mn; ocean bottom



## S E C T I O N 5

### FRESHWATER NODULES, CONCRETIONS, AND MANGANIFEROUS SEDIMENTS

This section lists reports relevant to lake and stream ferromanganese deposits, primarily those of the Great Lakes, Canada, and northeastern USA, as well as reports on European bog ore deposits.

FRESHWATER NODULES, CONCRETIONS, AND MANGANIFEROUS SEDIMENTS

Aarnio, 1917, 1918a,b	Fe-Mn concretions; Finnish lakes
Alfsen and Christie, 1972	S Norway; sedimentary Fe-ore pisolith; lake
Aschan, 1932	Peat bogs; participation in ore formation in northern fresh waters
Beak, 1966	Nova Scotia; Mn-Fe concretions; lakes
Beals and Trost, 1965	Mn concretions; biochem
Bortleson and Lee, 1974	Six Wisconsin lakes; P, Fe, Mn distrib in sed cores
Bowser, <u>et al.</u> , 1970	Wisconsin and Michigan; Fe-Mn nods; electron probe and x-ray studies
Buchanan, 1878	Scotland; Loch Fyne; Mn nods
Callender, 1968	Great Lakes; Mn; mineral resource
Callender, 1969	Lakes Michigan and Superior; geochem of seds
Callender, 1970	Great Lakes; Fe-Mn nods; economic potential
Callender, 1973	Green Bay, Lake Michigan; Fe-Mn crusts and nods; Mn carbonate crusts; geochem
Callender and Rossmann, 1970	Green Bay, Lake Michigan; sed geochem
Callender, <u>et al.</u> , 1973	Green Bay, Lake Michigan; Fe-Mn and Mn carbonate crusts; geochem
Calvert and Price, 1970c	Scotland; composition of Mn nods and Mn carbonates; lake
Clute and Grant, 1974	Chautauqua Lake, NY; organic matter and Fe-Mn concretions
Coey, <u>et al.</u> , 1974	Fe compounds in lake seds
Cronan and Thomas, 1970a	Lake Ontario; Fe-Mn concretions
Cronan and Thomas, 1970b	Lake Ontario; geochem of Fe-Mn oxide concretions



Cronan and Thomas, 1972	Lake Ontario; Fe-Mn oxide concretions and assoc deposits; geochem
Dahlberg and Keith, 1967	Distrib of trace metals in modern stream sed; three geologically different terranes
Dean, 1969	New York; Fe-Mn nod; lake
Dean, 1970	New York; Fe-Mn oxidate crusts; lake
Dean, <u>et al.</u> , 1973	Freshwater Fe-Mn nod; geochem and accretion rates
Delfino and Lee, 1968	Wisconsin; chem of Mn; lake
Delfino, <u>et al.</u> , 1969	Wisconsin; distrib of Mn, Fe, P, Mg, K, Na, and Ca in sed; lake
Edgington and Callender, 1970	Lake Michigan; Fe-Mn nod; minor element geochem
Ghosh and Dean, 1974	Oneida Lake, NY; factors contributing to precipitation of elements in Fe-Mn nod and assoc sed
Gillette, 1961	New York; Oneida Lake pancakes
Gorham and Swain, 1965	Lake sed; distrib of elements; influence of oxidizing and reducing conditions
Gurevich, 1964	Fe-Mn lake ores; formation; role of microorganisms
Halbach, 1974	Comparison of properties of limnic and marine Fe-Mn nod
Harriss and Troup, 1969	Fe-Mn concretions; chem and internal structure
Harriss and Troup, 1970	Fe-Mn concretions; chem and origin
Honeyman, 1881	Fe-Mn concretions; Nova Scotia lakes
Hunt and Henson, 1969	Lake Champlain; recent sedimentation and water properties
Hutchinson and Wollack, 1940	Connecticut; chem of sed ore; lake
Johnson, D. G., 1969	Lake Champlain; Fe-Mn concretions
Kindle, 1932	Mn concretions; lacustrine

Kindle, 1935	Nova Scotia; Mn concretions; lakes
Kindle, 1936	Canada; manganiferous deposits; lakes
Kovalev and Generalova, 1969	Recent peat bogs; Byelorussia; geochem aspects of movement of Fe
Kovalev and Lukashev, 1971	Geochem of Fe in peat bog process
Krotov, 1950	Formation of Fe and Mn hydroxides in lakes
Kurbatov, L. M., 1935, 1937	USSR; radioactivity of Fe-Mn formations; seas and lakes
Landergren, 1948	Swedish freshwater nodular accums
Ljunggren, 1953	Mn and Fe bog ores; Sweden; formation
Ljunggren, 1955a	Mn and Fe bog ores; Sweden; chem and radioactivity
Ljunggren, 1955b	Mn and Fe bog ores; Sweden; DTA and x-ray examination
Mackereth, 1966	Chem of post-glacial seds; lakes
Moore, E. J., 1910	Ontario; bog Fe deposits; occurrence and origin; lake
Moore, J. R., 1970	Green Bay, Lake Michigan; Mn-rich pellets; mineral resource
Mortimer, 1941, 1942	Dissolved substance exchange; mud to water; lakes
Mortimer, 1971	Great Lakes; seds and water; chem exchange; regulatory mechanisms
Naumann, 1922	Mn-Fe lake ore; Sweden
Naumann, 1930	European inland waters; shapes of freshwater ore nodules
Nichol, <u>et al.</u> , 1967	Stream sed; geochem patterns; precipitation of Mn oxides
Robbins and Callender, 1973	S Lake Michigan; Mn distrib in seds
Rossmann and Callender, 1968	Lake Michigan; Mn nod

Rossmann and Callender, 1969	Lake Michigan; Mn nodds; geochem
Schoettle and Friedman, 1971	New York; Fe-Mn nodds; lake
Shterenberg, <u>et al.</u> , 1966	USSR; Mn and Fe carbonates in bottom deposits; lake
Sokolova-Dubinina and Deryugina, 1967	Lake Punnus-Yarvi; study of formation of Fe-Mn nodds
Terasmae, 1967	Ontario; Mn-Fe concretions; lake
Terasmae, 1971	Mn-Fe concretions; lacustrine
Troup, 1969	Lacustrine Fe-Mn concretions; geochem investigations
Twenhofel and McKelvey, 1941	Seds in freshwater lakes
Varentsov, 1972a	Eningi-Lampi lake, central Karelia; geochem studies on formation of Fe-Mn nodds and crusts in recent basins
Varentsov, 1972b	Karelian lake; main aspects of formation of Fe-Mn ores in recent basins
Vogt, Th., 1942	Norwegian bog ores; chem composition
Zumberge, 1952	Minnesota lakes; origin and classification



## S E C T I O N 6

### SOIL NODULES AND CONCRETIONS

This section contains publications on iron, manganese, and associated elements in terrestrial soils and the weathering profile, including desert varnish.

## SOIL NODULES AND CONCRETIONS

- Adetunji, 1966 Fe-Mn concretions; soils; Britain
- Aristovskaya, 1965 Microbiology of podzolic soils
- Baker, 1973 Tasmanian podzolic soils; mineral degradation and metal mobilization; role of humic acids
- Barnhisel, et al., 1969 Fe and Mn in soils and concretions; x-ray fluorescence
- Blume, 1968 Mottling and nodule formation; poorly drained soils
- Boussingault, 1882 Appearance of Mn on rock surfaces
- Bromfield and Skerman, 1950 Biological oxidation of Mn; soils
- Brooks, R. R., 1965 New Zealand yellow-grey earth; gleyed and concretionary material; distrib of Fe-family elements
- Bryan, 1952 Soil nods; significance
- Collins and Buol, 1970a Fe and Mn precipitation; Eh-pH conditions
- Collins and Buol, 1970b Eh-pH environment; Fe and Mn equilibria
- Conry and Ryan, 1965 Mn in soils; West Cork, Ireland
- Crawford, 1969 Growth of Fe-Mn concretions; Wales
- Drosdoff and Nikiforoff, 1940 Fe-Mn concretions in soils; Dayton
- Ellis, et al., 1970 Diffusion of Cu, Mn, and Zn; soil
- Engel and Sharp, 1958 Desert varnish; chem data
- Fujimoto and Sherman, 1948 Mn in soil and Mn cycle; behavior
- Gallaher, et al., 1972 Soil concretions; preparation for analysis
- Helbig, 1914 Soil cementation resulting from Mn and lime

Hemstock and Low, 1953	Mn in colloidal fraction of soil
Hooke, <u>et al.</u> , 1969	Desert varnish; electron probe study
Hunt, 1954	Desert varnish
Ignatieff, 1941	Ferrous iron in soils
Jenne, 1968	Mn, Fe, Co, Ni, Cu, and Zn in soils and water; control by hydrous Mn and Fe oxides
Karavayeva, 1968	Iron pans in taiga zone; Australia
Lakin, Hunt, <u>et al.</u> , 1963	Desert varnish; minor element content
Lawrence and Taylor, 1971	Quaternary soils vs meteoritic waters; clay minerals and hydroxides; deuterium and oxygen-18
Leeper, 1947	Mn in soil
Leeper and Swaby, 1940	Oxidation of manganous compounds by microorganisms in soil
Mann and Quastel, 1946	Mn metabolism in soils
McKenzie, 1967	Sorption of cobalt by Mn minerals; soils
McKenzie, 1970	Reaction of cobalt with Mn-dioxide minerals
McKenzie and Taylor, 1968	Cobalt and Mn oxide minerals; soils
Patrick and Turner, 1968	Water-logged soil; Mn-transformation; effect of redox potential
Pelisek, 1936	Fe-Mn rich concretions; chem composition; "adobe-dirt"
Phillippe, <u>et al.</u> , 1972	Distrib of concretions; soils; Kentucky
Ponnamperuma, Loy, and Tianco, 1969	Redox equilibria; Mn oxide systems; flooded soils
Ponnamperuma, Tianco, and Loy, 1967	Redox equilibria, Fe hydroxide systems; flooded soils

Presant, 1971	New Brunswick; Fe, Mn, Pb, Cu, Zn, As, Sb, Ag, Sn, and Cd; soils; geochem
Redden and Porter, 1962	Soil concretions; Virginia Piedmont
Robinson, 1929	Mn dioxide in soil
Robinson, 1930	Chem phases; submerged soil
Roslikova, 1961	Mn-Fe concretions; soils; Suifenko-Khanka Depression
Saunders, 1965	New Zealand soils; relationship of free sesquioxides, organic matter, etc to phosphate retention
Schellman, 1971	Lateritic Fe, Ni, Al, and Mn; relation to source rock
Sherman, 1959-1960	Minerals, concretions, nodules, and layers of soil
Sherman and Kaneshiro, 1954	Origin and development of Fe concretions; latosols; Hawaii
Sherman, <u>et al.</u> , 1949	Origin and composition of pyrolusite concretions; soils; Hawaii
Smith, L. L., 1948	Hollow ferruginous concretions; South Carolina
Sokolova, T. A. and Polteva, 1968	Fe-Mn concretions; podzolic soil; Australia
Taylor, R. M. and McKenzie, 1966	Trace elements and Mn minerals; soil; Australia
Te Punga, 1954	New Zealand; Late Pleistocene buckshot gravels
Thresh, 1902	Mn nodules; Essex
Todd, 1903	Concretions; morphology; land and ground water
Tsukunaga, 1932	Formation of Fe concretions; soils; Manchuria
Vinayak, <u>et al.</u> , 1964	Mn in saline-alkali soils
Walker, 1964	Pedogenesis of ferruginous formations; Hawaii



Wheeting, 1936

Williamson and Burgin, 1959

Winters, 1938

Yaalon, et al., 1972

Zvorykin, 1934

Shot soils; W Washington

Mn in weathering zone

Fe-Mn concretions; podzolic soils

Mn in soils; Mediterranean

Red earth ferrous concretions; Greece



## S E C T I O N 7

### "FOSSIL" MANGANESE NODULES

This section contains reports on manganese nodules and associated marine deposits that formed on ancient seafloors, now uplifted and exposed on land, particularly those found in the Alps, on Cyprus and Sicily, and in Indonesia.

"FOSSIL" MANGANESE NODULES

- Audley-Charles, 1965                      Geochem of Cretaceous Fe-Mn sed rocks;  
Timor
- Constantinou and Govett, 1972            Genesis of sulfide deposits, ochre and  
umber; Cyprus
- Corliss, et al., 1972                    Rare earth data for Fe- and Mn-rich  
seds assoc/w sulfide ore bodies;  
Troodos Massif, Cyprus
- Doherty, 1898                              Mn nods found at Onybygambah
- Elderfield, et al., 1972                Origin of Fe-Mn seds; Troodos Massif,  
Cyprus
- El Wakeel and Riley, 1961a                Chem and mineralogy of fossil red  
clays; Timor
- Fabricus, 1968                             Calcareous Raetian and Lower Jurassic  
sea bottoms; NW Alps
- Fischer and Garrison, 1967                Carbonate lithification on sea floor
- Garrison and Fisher, 1969                 Alpine Jurassic; deep-water limestone  
and radiolarites
- Gattrall, et al., 1972                    Jurassic limonitic concretions;  
southern England
- Germann, 1971                             Mn and Fe-bearing nods and crusts;  
Jurassic red limestones; N Limestone  
Alps
- Govett and Pantazis, 1971                 Distrib of Cu, Zn, Ni, Co; Troodos  
Pillow Lava Series, Cyprus
- Grunwald, 1964                            Mn concretions in Pierre Shale, South  
Dakota; mineralogy and origin
- Gulbrandsen, 1965                         Permian Mn nods
- Gulbrandsen and Reeser, 1969             Permian Mn nods; Dillon, Montana
- Hallam, 1967                              Red limestones; Alpine Lias;  
sedimentology and paleogeographic  
significance
- Heim, 1924                                 Mn nods from Lower Jurassic limestones  
of Austria

Hurley, 1966	Fe-Mn pancakes in Cenozoic limestones dredged off Barbados
Jenkyns, 1967	Fossil Mn nods; Sicily
Jenkyns, 1970a	Submarine volcanism of Toarcian Fe pistolites; West Sicily
Jenkyns, 1970b	Fossil Mn nods; West Sicilian Jurassic
Jenkyns and Torrens, 1969	Paleogeographic evolution of Jurassic seamounts; West Sicily
Jurgan, 1967	Genesis and facies of Lias seds Alps
Jurgan, 1969	Lias sedimentology; calcareous Alps
Kovacs, 1956	Mn precipitation on Jurassic marine ammonites
Kuenen, 1942	<u>Snellius</u> expedition; geological results; bottom samples
Lindström, 1974	Volcanic contribution to Ordovician pelagic seds
Litherland and Malan, 1973	Precambrian of Botswana; manganiferous stromatolites
Molengraaf, 1916	Mn nods in Mesozoic deep-sea deposits; Borneo, Timor, and Rotti
Molengraaf, 1922	Mn nods in Mesozoic deep-sea deposits; Timor
Park, 1946	Spillite and Mn problems; Olympic Peninsula, Washington
Pieruccini, 1951	Northern Toscana Appenines; diffusion of Mn in limestones and chert seds
Rech-Frollo, 1971	Red limestones; composition and origin; Alps
Robertson, A. H. F. and Hudson, 1973	Cyprus umbers; chemical precipitates on a Tethyan ocean ridge
Sigal and Truillet, 1966	Chem analysis of Fe-Mn accums in Jurassic red limestones, Sicily

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|----------------------|---|
| Sokolow, 1901        | Mn deposits in shallow marine<br>Tertiary strata of Russia                                    |
| Sorem and Gunn, 1966 | High-temperature Tertiary Mn nodds;<br>Olympic Peninsula, Washington                          |
| Tucker, 1971         | Devonian Mn nodds; France   |
| Tucker, 1973         | Devonian Fe-Mn nodds; France and West<br>Germany  |
| Wendt, 1969          | Red Jurassic limestones; stratigraphy<br>and paleogeography; Austria                          |
| Wendt, 1970          | Stratigraphic condensation in Triassic<br>and Jurassic cephalopod limestones of<br>the Tethys |

## S E C T I O N 8

### TERRESTRIAL MANGANESE OCCURRENCES

#### a - MANGANESE ORE DEPOSITS

This section contains reports on terrestrial manganese ore deposits, including bog ores.

#### b - MANGANESE IN ROCKS

This section contains reports on manganese found in sedimentary, metamorphic, and igneous rocks.

## MANGANESE ORE DEPOSITS

- Alexandrov, 1962 Sed cycle of Mn and its practical implication
- Allsman, 1956 Butte, Montana; oxidation and enrichment of Mn deposits
- Band, 1967 Fiji; Mn
- Baranova and Gevork'yan, 1968 S Ukraine; Oligocene manganosiderites
- Basta and Saleeb, 1971 Egypt, SE Desert; Elba Mn ores; origin
- Borchert, 1970 Mn, ore-deposition and geochem
- Buckenham, 1961 Viti Levu, Fiji; beneficiation of Mn ores
- Constantinou and Govett, 1972 Cyprus; genesis of sulfide deposits, ochre and umber
- Dzotsenidze, 1966 Chiatura Mn deposit; genesis
- Efimova and Nikolaev, 1965 Fe-Mn concretions and Mn ores; radiochem composition
- Ferguson and Lambert, 1972 Matupi Harbor, New Britain; volcanic exhalations and metal enrichments
- Govett and Pantazis, 1971 Distrib of Cu, Zn, Ni, Co; Troodos Pillow Lava Series, Cyprus
- Hewett, 1964 SW United States; hypogene Mn oxide mineral veins
- Hewett, 1972 Manganite, hausmannite, braunite: features and origin
- Hewett and Fleischer, 1960 Mn oxide deposits
- Hewett, et al., 1963 Mn oxide deposits; supplement
- Kim, 1972 South Korea; Mn deposits
- Lahiri, 1971 Madhya Pradesh, India; Mn oxides and silicate rocks; mineralogy and genesis
- Landergren, 1948 Sweden; Fe ores and assoc rocks; geochem



- Larson, 1962a                      Philipsburg, Montana; geology and mineralogy of certain Mn oxide deposits
- Larson, 1962b                      Philipsburg, Montana; Zn-bearing todorokite
- Larson, 1964                        Mn oxide deposits; geology and mineralogy
- Larson, 1969, 1970                Tennessee; Fort Payne Formation; Co and Ni-bearing Mn oxides
- Lee, D. E., 1955                    Mineralogy of some Japanese Mn ores
- Listova, 1961                        Physiochem conditions of formation of Mn oxide and carbonate ores
- Litherland and Malan, 1973        Manganiferous stromatolites; Precambrian of Botswana
- Ljunggren, 1953                    Mn and Fe bog ores; formation
- Ljunggren, 1955a                   Mn and Fe bog ores; chem and radioactivity
- Ljunggren, 1955b                   Fe and Mn in bog ores; DTA and x-ray examination
- Lonie and McIntosh, 1974        Groote Eylandt, Northern Australia; occurrence and development of sedimentary Mn ore
- Magaritz, 1969                      S Negev and Sinai; Mn deposits; trace elements
- Mart and Sass, 1972                Sinai, Israel; Mn ore; geology and origin
- Mitchell and Garson, 1972        Porphyry copper and circum-Pacific tin deposits: relation to paleo-Benioff zones
- Mohr, 1955, 1959                   N Wales, Harlech Dome; Lower Cambrian Mn shale; geochem
- Mohr, 1956                          N Wales, Harlech Dome; Lower Cambrian Mn ore; geochem
- Mohr, 1964                          N Wales, Cambrian Mn carbonate rocks; genesis

Moore, E. J., 1910	Thunder Bay, Ontario; bog Fe deposits; occurrence and origin
Naganna and Bouška, 1963	Sandur ore deposits, Mysore State, India; x-ray study of woodruffite
Nambu and Tanida, 1961	Toyoguchi mine, Iwate Prefecture (Japan); progressive alteration of MnO <sub>2</sub>
Ossa, 1970	N Chile; Mn deposits; genesis
Paakkola, 1971	Finnish Lapland; volcanic complex and assoc manganiferous Fe formation
Park, 1946	Olympic Peninsula, Washington; spilite and Mn problems
Park, 1972	Land areas around Pacific Basin; Fe ore deposits
Park and MacDiarmid, 1964	Sed Mn ore deposits
Ramdohr and Frenzel, 1956	Mn ores
Reed, 1960	New Zealand; Mn ore
Sapozhnikov, 1967	USSR; Mn deposits; formation
Shatskiy, 1964	Volcanic-sedimentary manganiferous formations
Simons and Straczek, 1958	Mn deposits of Cuba; geology
Skey, 1877	Cobalt in Mn ores
Skiba, 1964	SW Viti Levu, Fiji; geological studies
Smith, W. C. and Gebert, 1970	Groote Eylandt, Australia; Mn
Sokolova, E. I., 1964	Sed Fe and Mn areas and assoc rocks; physiochem
Sorem and Cameron, 1960	W Africa; Nsuta deposits; Mn oxides and assoc minerals
Sorem and Gunn, 1967	Olympic Peninsula, Washington; Mn deposits; mineralogy
Strakhov and Shterenberg, 1966	Chiatura deposit; genetic type

Taliaferro and Hudson, 1943	California, coast ranges; Mn deposits; genesis
Tavera and Alexandri, 1972	Hidalgo, Mexico; Melango Mn deposit
Thonis and Burns, 1974	Mn ore deposits and plate tectonics: evidence of three loci of Mn mineralization in orogenic belts
Varentsov, 1964	Sed Mn ores
Vogt, J. H. L., 1906	Mn-like metals; behavior toward Fe and Mn in ocean and trace-metal ores
Waal, 1969	N Cape Province, S Africa; Hotazel mine; ramsdellite
Warden, 1970, 1971	New Hebrides; Forari Mn deposit; genesis
Wasserstein, 1943	Boron in braunite and Mn ores
Wilson, M. J., Berrow, and McHardy, 1970	Banffshire; Lecht mines; lithiophorite
Woodland, 1939	W Merionethshire (UK); Lower Cambrian Mn ore; petrography and petrol
Wyn Hughes, 1971	Malaita Island, British Solomon Islands; zoned nodules
Yoshimura, 1934	Hokkaido, Japan; Todoroki mine; todorokite
Yoshimura, 1953	Japan; types of Mn deposits
Zappfe, 1931	Deposition of Mn

MANGANESE IN ROCKS

- Curtis, 1967 Britain; Carboniferous seds; diagenetic Fe minerals
- Curtis and Spears, 1968 Formation of sed Fe minerals
- Dale, 1915 Conception and Trinity Bays, Newfoundland; Cambrian Mn deposits
- Finkelman, et al., 1974 Chihuahua, Mexico; Mn minerals in geodes \*
- Finkelman, Matzko, et al., 1972 Minerals in geodes from Chihuahua, Mexico; SEM study
- Grunwald, 1964 South Dakota; Pierre Shale; Mn concretions; mineralogy and origin
- Gunn and Sorem, 1965 Near Enterprise, Oregon; occurrence of the Mn oxides todorokite and rancieite
- Larson, 1969, 1970 Co- and Ni-bearing Mn oxides from Fort Payne Formation, Tennessee
- LeRoy, 1949 W Venezuela; El Milagro Formation; voidal concretions
- Makharadze, 1972 W Georgia (USSR); Lower Oligocene seds; source and transfer of Mn, Si, Fe and P
- Mohsen and Brounlow, 1971 Montana; W Philipsburg batholith; Mn
- Park, 1946 Olympic Peninsula, Washington; spilite and Mn problems
- Perseil, 1966 Todorokite in marbled limestone from upper Devonian of Las Cabesses (Ariège)
- Pieruccini, 1951 N Toscana Appenines; diffusion of Mn in limestone and chert seds
- Ronov and Yermishkina, 1959 Mn distrib in sed rocks
- Sokolow, 1901 Gov'ts Jekaterinislaw; Tertiary strata; Mn deposits

Sorem and Gunn, 1965

Secondary Mn oxide minerals in  
Washington and NE Oregon

Thresh, 1902

Mn nods in Essex

Veymarn, et al., 1972

Mn mineralization in Devonian red beds;  
hydrothermal sed origin; west-central  
Kazakhstan

Voronov and Spiro, 1965

E Antarctica, coast; Quaternary  
deposits; distrib of oxides and  
hydroxides



## S E C T I O N 9

### CHEMICAL COMPOSITION OF NODULES

This section lists publications that report chemical analyses (one or more elements) of marine and freshwater manganese nodules.

## CHEMICAL COMPOSITION OF NODULES

- |                                     |  |
|-------------------------------------|--|
| Ahrens, <u>et al.</u> , 1967        | Mn nods; rarer element composition   |
| Andrushchenko and Skornyakova, 1967 | Mn nods; composition, structure and features of formation; Pacific Ocean             |
| Bacon, 1967                         | Mn nods; geochem   |
| Barnes, S. S., 1967a                | Mn nods; mineralogy and chem   |
| Barnes, S. S., 1967b                | Oceanic Fe-Mn nods; formation  |
| Barnes, S. S., 1967c                | Fe-Mn nods; minor element composition  |
| Bertine and Turekian, 1973          | Mo in marine deposits  |
| Bezrukov and Andrushchenko, 1974    | Fe-Mn nods; geochem; Indian Ocean  |
| Bhat, <u>et al.</u> , 1970          | Fe-Mn nods; radiometric and trace elemental studies                                  |
| Brown, B. A., 1968                  | Mn nods; observations and analyses   |
| Brown, B. A., 1971                  | Deep-sea Fe-Mn nods; geochem; inter-element relations                                |
| Buchanan, 1876                      | Chem and geological work done on board HMS <u>Challenger</u>                         |
| Buchanan, 1891                      | Mn nods; ocean and littoral; composition   |
| Buchowiecki and Cherry, 1968        | Th, Ra, K in Mn nods   |
| Burns, R. G., 1965                  | Mn nods; cobalt (III) in amorphous $\text{FeOOH} \cdot n\text{H}_2\text{O}$ phase    |
| Burns, R. G., 1966                  | Mn nods; trace elements; electron-probe investigation                                |
| Burns, R. G. and Brown, 1972        | Mn nod composition; nucleation and mineral controls                                  |
| Burns, R. G. and Fuerstenau, 1966   | Mn nods; electron probe inter-element relations                                      |
| Callender, 1973                     | Fe-Mn crusts, Mn carbonate crusts, and Fe-Mn nods; Green Bay, Lake Michigan; geochem |



Callender, <u>et al.</u> , 1973	Fe-Mn and Mn carbonate crusts; Green Bay, Lake Michigan; geochem
Calvert and Price, 1970c	Mn nods and Mn carbonates; Loch Fyne, Scotland; composition
Chester, <u>et al.</u> , 1973	Deep sea clays and Mn nods; SW region of North Atlantic; similarities between Mn, Ni, Co contents
Chow and McKinney, 1958	Pb in Mn nods; mass spectrometric determination
Chow and Patterson, 1959a	Pb isotopes in Mn nods
Chow and Patterson, 1959b	Pelagic seds and Mn nods; Pb; isotopic composition and concentration
Crocket, Harriss, and MacDougall, 1969	Palladium, gold, iridium; marine geochem
Cronan, 1967	Mn nods and assoc pelagic seds; geochem
Cronan, 1969a	Fe-Mn deposits; ocean; geochem
Cronan, 1969b	Mn nods; chem and mineralogical variations with depth
Cronan, 1972a	Fe-Mn nods; world ocean; regional geochem
Cronan, 1972b	Mn nods; Atlantic; composition
Cronan and Thomas, 1970b	Fe-Mn oxide concretions; Lake Ontario; geochem
Cronan and Tooms, 1967b	Mn nods; NW Indian Ocean; geochem
Cronan and Tooms, 1968	Mn nods; NW Indian Ocean; microscopic and electron probe investigation
Cronan and Tooms, 1969	Mn nods and assoc pelagic deposits; Pacific and Indian Oceans; geochem
Dean, <u>et al.</u> , 1973	Fe-Mn nods; freshwater; geochem and accretion rates
Dieulafait, 1883	Mn in sea water and certain of its deposits

Dunham and Glasby, 1970	Mn nods; electron probe investigation
Dunham and Glasby, 1974	Some deep- and shallow-water Mn nods; petrographic and electron microprobe investigation
Edgington and Callender, 1970	Fe-Mn nods; Lake Michigan; minor elements geochem
Efimova and Nikolaev, 1965	Fe-Mn concretions and Mn ores; radiochem composition
Ehrlich, A. M., 1968	REE in Mn nods
Ehrlich, A. M. and Winchester, 1967	REE in Mn nods
El Wardani, 1958	Marine geochem of germanium and origin of Pacific pelagic clay minerals
Fein and Morgenstein, 1972, 1973	Mn crusts; Hawaiian Archipelago; microprobe analysis
Firth, 1969	Mn nods, seds and sea water; mineralogy and chem
Fomina, 1966	REE; accum and redistrib during Fe-Mn concretion formation
Fomina and Volkov, 1969	REE in Fe-Mn concretions; Black Sea
Fomina and Volkov, 1971	REE in seds and Fe-Mn nods
Frazer, F. W. and Ostwald, 1970	Suite of deep-sea Mn nods; chem and mineralogical investigations
Frazer, J. Z. and Arrhenius, 1972	Element concentrations in Mn nods; distrib of Fe-Mn nods
Friedrich, Kunzendorf, and Plüger, 1973	Mn nods; Pacific; geochem investigations; EDX-technique; <u>Valdivia</u>
Friedrich, Rosner, and Demirsoy, 1969	Mn concretions; Pacific; micro-studies
Ganung and Lasko, 1966	Mn nods; structure and composition

Ghosh and Dean, 1974	Factors contributing to precipitation of elements in Fe-Mn nodules and associated sediments
Glagoleva, 1971	Fe-Mn nodules in sediments; NW Pacific; change of chemical composition
Glagoleva, 1972	Fe-Mn concretions in sediments; NW Pacific; characteristics of changes in chemical composition
Glasby, 1970	Mn nodules and associated pelagic sediments; Indian Ocean; geochemistry
Glasby, 1971	Mn nodules and associated pelagic sediments; Indian Ocean; geochemistry
Glasby, 1972e	Mn nodules; NW Indian Ocean; geochemistry
Glasby, 1972g	Mn nodules; marine; Fe oxide phase
Glasby, 1973b	Mn deposits of variable composition; north of Indian-Antarctic Ridge
Glasby, 1974a	Exploitation of Mn nodules; South Pacific
Glasby, 1974b	Mn and associated trace elements in marine Mn nodules; mechanisms of incorporation
Glasby, Tooms, and Cann, 1971	Mn encrustations; Gulf of Aden; geochemistry
Glasby, Tooms, and Howarth, 1974	Mn concretions; NW Indian Ocean; geochemistry
Goodell, 1968b	Elemental distribution in Fe-Mn concretions; Southern Ocean
Gorshkova, 1931	Barents Sea and White Sea nodules; chemical analysis
Gorshkova, 1961	Neritic concretions; chemical analysis
Grant, 1967	Mn concretions; Southern Oceans; chemical, mineralogy, distribution and physical aspects
Grant, 1968	Fe-Mn concretions; Southern Ocean; morphology and composition; environmental controls

Grasshoff, 1970	Chem of Mn nodds
Greenslate, 1973	Pacific nodds; Scripps data
Greenslate, Frazer, and Arrhenius, 1973	Distrib of elements between soluble and insoluble phases of Mn nodds
Halbach, 1974	Limnic and marine Fe-Mn nodds; comparison of properties
Han, 1971	Mn nodds; ocean; geochem and extraction of metals
Harriss, 1968	Mercury in Mn nodds; ocean
Harriss and Crocket, 1968	Mn nodds; geochem of palladium, iridium, and gold
Harriss and Troup, 1969	Fe-Mn concretions; freshwater; chem and structure
Harriss and Troup, 1970	Fe-Mn concretions; freshwater; chem and origin
Harriss, <u>et al.</u> , 1968	Mn nodds; ocean; palladium, iridium, and gold
Haskin, <u>et al.</u> , 1966	REE in Mn nodds, sedds, and sea water
Heady, 1967	Mn nodds; marine; collection and analysis
Hoover, 1966	Dissolution of Cu, Ni, and Co from oceanic Mn nodds
Horn, D. R., 1972b	Worldwide and Pacific distrib and metal content of Mn deposits; ocean
Horn, D. R., and Horn, 1973	Metal content of Fe-Mn deposits; ocean; worldwide
Horn, D. R., Delach, and Horn, 1973	Fe-Mn deposits; ocean; metal content
Horn, D. R., Horn, and Delach, 1973a	Mn nod metal values and mining sites; ocean
Horn, D. R., Horn, and Delach, 1973b	Cu and Ni in ocean Fe-Mn deposits; relation to substrate

Horn, D. R., Horn, and Delach, 1974	Ni- and Cu-rich nods; Equat Pacific
Hubred, 1970b,c	Mn nods; abyssal hill; morphology and metal content
Isayeva, 1967	Fe-Mn concretions; Indian Ocean; chem
Kawashima, <u>et al.</u> , 1961	Lanthanum, samarium and europium in Mn nods; determination by neutron activation
Ku and Broecker, 1967a	U, Th, Pa in Mn nod
Kuo and Crocket, 1973	Sources of Ir, Pd, Au in deep-sea deposits
Lakin, Thompson, and Davidson, 1963	Tellurium content of marine and other Mn oxides
Manheim, 1961	Baltic Sea nods; chem analysis
Manheim, 1965b	Mn-Fe accums; shallow marine
Manheim, 1972	Mn-Fe nods and pavements; Blake Plateau; composition and origin
Manheim and Pratt, 1968	Mn-phosphorite deposits; Blake Plateau; geochem
Manheim, Pratt, and McFarlin, 1967	Mn and phosphate deposits; geochem
Matthews, 1954	Mn nods; investigation of Th content using nuclear plates
Mero, 1962	Ocean-floor Mn nods
Mero, 1965	Mineral resources of the sea
Meyer, 1973a,b	Surface sed and Mn nod facies; NE Pacific; <u>Valdivia</u> , 1972-73
Murray, J. and Irvine, 1894	Neritic and deep-sea nods; chem analysis
Murray, J. and Philippi, 1908	Atlantic nods
Murray, J. and Renard, 1891	Mn nods; <u>HMS Challenger</u>
Nayudu, 1973	Deep sea Mn nods; subantarctic Pacific; geochem

Okada, Okada, and Shima, 1972	Fe in Mn nod; chem form
Ostwald and Frazer, 1973	Deep sea Mn nods; Southern Ocean; chem and mineralogical investigation
Pachadzhyanov, <u>et al.</u> , 1963	Mn nods; Indian Ocean; geochem
Piper, 1972	REE in Mn nods; Pacific
Piper, 1973a	REE in Fe-Mn nods; ocean
Piper, 1974	REE in Fe-Mn nods and other marine phases
Price, 1967	Mn-Fe oxides (nods); depth geochem
Price and Calvert, 1970	Fe-Mn nods; Pacific; compositional variation; relation to sed accum rates
Raab, 1972	Mn nods; genesis; physical and chem features
Rancitelli and Perkins, 1973	Mn nods; ocean; elemental composition
Reynolds and Dasch, 1970	Pb isotopes in marine Mn nods
Reynolds and Dasch, 1971	Pb isotopes in marine Mn nods; ore-lead growth curve
Riley and Sinhaseni, 1958	Mn nods; Pacific; chem composition
Sano and Matsubara, 1970	Mn nods; aspects of element distrib
Scott, M. R., Scott, Rona, <u>et al.</u> , 1974	Rapidly accumulating Mn deposit; median valley of Mid-Atlantic Ridge
Sevast'yanov, 1967	Redistrib of arsenic during formation of Fe-Mn concretions; Black Sea sed
Sevast'yanov and Volkov, 1966	Fe-Mn concretions; Black Sea; chem
Sevast'yanov and Volkov, 1967	Formation of Fe-Mn nods; redistrib of elements in oxidized layer; Black Sea sed
Skornyakova, <u>et al.</u> , 1962	Fe-Mn nods; Pacific; chem
Smith, J. D. and Burton, 1972	Tin; occurrence and distrib; worldwide marine
Smith, R. E., <u>et al.</u> , 1968a	Fe-Mn nods; Nares Abyssal Plain; geochem

Smith, R. E., <u>et al.</u> , 1968b	Fe-Mn nods; Nares Abyssal Plain; geochem
Somayajulu, 1967	Beryllium-10 in Mn nod
Sparks, 1971	Light elements in Mn nods; charged particle activation analysis
Sparks and Glasby, 1973	Light elements in marine Mn nods; application of charged particle activation analysis
Takeda, 1974	Deep sea mineral resources in NW Pacific; investigations
Tooms, <u>et al.</u> , 1969	Phosphate and Mn deposits; marine; geochem
Topping, 1969	Mn, Co, Cu, Fe, and Zn concretions; N Indian Ocean and Arabian Sea
Troup, 1969	Lacustrine Fe-Mn concretions; geochem investigations
Turekian, 1968	Deep-sea deposition of Ba, Co, Ag
Varentsov, 1972a	Fe-Mn nods and crusts in recent basins: Eningi-Lampi lake, central Karelia; geochem studies on formation
Varentsov, 1973	Fe-Mn ores in shelf regions of recent seas; geochem aspects of formation
Vogt, Th., 1942	Norwegian bog ores; chem composition
Volkov and Fomina, 1967	Rare-earth elements in seds and Mn concretions; ocean
Willis, 1970	Mn nods; composition and trace elements
Willis and Ahrens, 1962	Mn nods; composition and trace elements
Willis, Kaye, and Ahrens, 1964	Thallium in granites and Mn nods; spectrochem estimation
Winterhalter and Siivola, 1967	Distrib of Fe, Mn, and P in concretions; Baltic; electron microprobe study





S E C T I O N 1 0

CHEMICAL COMPOSITION OF SEDIMENTS ASSOCIATED WITH MANGANESE NODULES

This section contains publications that include coverage of the chemical composition of marine and freshwater sediments that are associated with ferromanganese accumulations.

CHEMICAL COMPOSITION OF SEDIMENTS ASSOCIATED WITH MANGANESE NODULES

Amano, <u>et al.</u> , 1967	Ni content; vertical distrib; deep-sea core
Amin, <u>et al.</u> , 1966	Cosmogenic Be <sup>10</sup> and Al <sup>26</sup> in marine seds
Angino, 1965	Trace-element chem; Recent Antarctic glacial-marine seds
Angino, 1966	Geochem of Antarctic pelagic seds
Angino and Miller, 1966	Chem criteria for recognition of glacial marine seds
Anikouchine, 1967	Chem substances in marine seds
Arrhenius, Bramlette, and Picciotto, 1957	Radioactive and stable heavy nuclides in seds; ocean
Baas Becking, and Moore, 1959	Fe and organic matter in seds
Barker and Anders, 1968	Iridium and osmium in seds; cosmic matter; ocean
Baturin, 1973	Uranium in the modern marine sedimentary cycle
Baturin, <u>et al.</u> , 1969	Fe-ore seds and hot brines; Red Sea; composition and origin
Belov, <u>et al.</u> , 1966	Fe, Mn carbonates and organic matter in seds; distrib; Arctic Ocean
Bender, 1971	Mn in pelagic seds; upward diffusion
Bender and Schultz, 1969	Trace metals in cores; distrib; Indian Ocean
Bender, Broecker, <u>et al.</u> , 1970	Mn and related elements in seds; accum rate; East Pacific Rise
Bender, Broecker, <u>et al.</u> , 1971	Geochem of cores; East Pacific Rise
Berner, 1971	Chemical sedimentology

Berritt and Rotschi, 1956	Chem analyses of cores from central and West Equat Pacific
Bertine and Turekian, 1973	Mo in marine deposits
Blissenbach, 1972	Continental drift and metalliferous seds
Bonatti, 1971	Mn fluctuations in sed cores; Caribbean
Bonatti, Fisher, <u>et al.</u> , 1971	P, U, and Th in sed; mobility of elements; ocean
Bortleson and Lee, 1974	P, Fe, Mn distrib in sed cores from six Wisconsin lakes
Boström, 1967b	Excess Mn in pelagic seds
Boström, 1967c	Elements of economic interest, origin of; deep-sea sed
Boström, 1970a	Mn-rich sed; deposition of; glacial periods
Boström, 1970b	Ocean floor spreading; geochem evidence for; South Atlantic
Boström, 1970e	Fe-rich sed; origin of; East Pacific Rise
Boström, 1970f	Mn-rich sed layers; origin of; Arctic Ocean
Boström and Fisher, 1969	Mercury in sed; distrib of; East Pacific
Boström and Fisher, 1971	Volcanogenic U, V, Fe in Indian Ocean sed
Boström and Peterson, 1969	Ferromanganoan sed; origin of; high heat flow areas; East Pacific Rise
Boström, Kraemer, and Gartner, 1973	Opaline silica, Al, Ti, Fe, Mn, Cu, Ni, Co in Pacific pelagic sed; provenance and accum rates
Boström, Joensuu, Moore, <u>et al.</u> , 1973	Geochem of barium in pelagic sed
Boström, Joensuu, Valdes, and Riera, 1972	Geochem history of sed; South Atlantic

Boström, Peterson, Joensuu, and Fisher, 1969	Fe-Mn seds; active oceanic ridges
Burnett, 1971	Rare metals in marine seds; central Pacific
Callender, 1969	Geochem of seds; Lakes Michigan and Superior
Callender and Rossmann, 1970	Geochem of seds; Lake Michigan
Calvert and Price, 1970b	Minor metal contents of recent organic-rich seds off SW Africa
Carvajal, 1967	Aspects on stability conditions of solids in sea water; distrib of Mn, Co, Ni in marine seds
Carvajal and Landergren, 1969	Mn, Co, and Ni; relation of; marine sed processes
Chester, 1965	Elemental geochem of seds; marine
Chester and Hughes, 1966	Mn, Fe, and Ni in core; distrib of; North Pacific
Chester and Hughest, 1967	Fe-Mn and carbonate minerals and trace elements from pelagic seds; chem technique for separation of
Chester and Hughes, 1969	Trace element geochem of pelagic core; North Pacific
Chester and Messiha-Hanna, 1970	Trace element partition patterns of seds; North Atlantic
Chester, <u>et al.</u> , 1973	Similarities between Mn, Ni, Co contents of deep sea clays and Mn nodules; SW region of North Atlantic
Chow, 1958	Pb isotopes in sea water and marine seds
Chow and Goldberg, 1960	Marine geochem of Ba
Chow and Patterson, 1959a	Isotopic composition and Pb in pelagic seds and Mn nodules
Clark, 1924	Data of geochemistry
Coey, <u>et al.</u> , 1974	Fe compounds in lake seds

Cook, 1971	Fe and Mn-rich seds over basalt; Equat Pacific
Corliss, <u>et al.</u> , 1972	REE data for Fe- and Mn-rich seds assoc/w sulfide ore bodies of Troodos Massif, Cyprus
Cortecci and Longinelli, 1972	Oxygen isotope variations in barite slab; sea bottom off S Calif
Crerar, Cormick, and Barnes, 1972	Sed geochem of Mn; organic controls
Crocket, Harriss, and MacDougall, 1969	Marine geochem of palladium, gold, and iridium
Crocket, MacDougall, and Harriss, 1973	Gold, palladium, iridium in marine seds
Cronan, 1964	Minor elements and isotopes in pelagic seds
Cronan, 1967	Geochem of Mn nods and assoc pelagic seds
Cronan, 1969c	Inter-element association in pelagic deposits
Cronan, 1969d	Avg abundances of Mn, Fe, Ni, Co, Cu, Pb, Mo, V, Cr, Ti, P in Pacific pelagic clays
Cronan, 1972c	Al, As, Hg, and Mn in ferruginous seds; median valley, Mid-Atlantic Ridge, 45°N
Cronan and Garrett, 1973a	Partition of elements in basal seds; East Pacific
Cronan and Garrett, 1973b	Distrib of elements in metalliferous Pacific seds collected during DSDP
Cronan and Tooms, 1969	Geochem of Mn nods and assoc pelagic deposits; Pacific and Indian Oceans
Cronan, van Andel, <u>et al.</u> , 1972	Fe-rich basal seds; E Equat Pacific

Dasch, 1968	Sr-isotope variations in size-fractionated, deep-sea seds and their relationship to marine diagenesis of clay minerals
Dasch, Dymond, and Heath, 1971	Isotopic analysis of metalliferous sed; East Pacific Rise
Dasch, Heath, and Dymond, 1971	Isotopic analysis of metalliferous sed; East Pacific Rise
Dasch, Hills, and Turekian, 1967	Sr isotopes in deep-sea seds and weathering profiles
Delfino, Bortleson, and Lee, 1969	Distrib of Mn, Fe, Mg, K, Na, and Ca in surface seds; lake; Wisconsin
Dieulafait, 1883	Mn in sea water and certain of its deposits
Durgaprasada Rao, <u>et al.</u> , 1970	Mn in bottom seds; E Bay of Bengal
Dymond, Corliss, <u>et al.</u> , 1972	Chem, isotopic and mineralogical study of DSDP and East Pacific Rise seds
Dymond, Heath, <u>et al.</u> , 1973	Elemental and isotopic geochem of metalliferous seds on East Pacific Rise
Elderfield, 1972b	Compositional variations in the Mn oxide component of marine seds
El Wakeel and Riley, 1961b	Chem and mineralogy of seds; ocean
El Wardani, 1958	Marine geochem of germanium and origin of Pacific pelagic clay minerals
Ericson and Wollin, 1973	Precipitation of Mn oxide in seds; ocean
Firth, 1969	Mineralogy and chem of Mn nods, seds, and sea water
Fisher, D. E. and Boström, 1969	Uranium-rich seds; East Pacific Rise
Fomina and Volkov, 1971	REE in seds and Fe-Mn nods
Ganapathy, <u>et al.</u> , 1968	Adsorption of trace elements by near shore sea bed seds

Gieskes, <u>et al.</u> , 1974	Geochem evidence for extensive diagenesis in DSDP Hole 245
Glasby, 1970	Geochem of Mn nodds and assoc pelagic seds; Indian Ocean
Glasby, 1971	Geochem of Mn nodds and assoc pelagic seds; Indian Ocean
Glasby, 1972h	Trace element geochem of pelagic seds; influence of manganiferous fragments; NW Indian Ocean
Glasby, 1973b	Mn deposits of variable composition; north of Indian-Antarctic Ridge
Goel, <u>et al.</u> , 1957	Be <sup>10</sup> concentrations in deep-sea seds
Goldberg, 1961b	Chem and mineralogy of seds; ocean
Goldberg, 1963b	Mineralogy and chem of marine sedimentation
Goldberg and Arrhenius, 1958	Chem of pelagic seds; Pacific
Goldberg and Koide, 1958	Ionium-thorium chronology; seds; Pacific
Goldberg, Koide, <u>et al.</u> , 1963	REE distrib; marine
Gorshkova, 1931	Chem and mineralogy of seds; Barents and White Seas
Gorshkova, 1957	Composition of Kara Sea seds
Gorshkova, 1958	Organic matter and carbonates in seds; Barents Sea
Gorshkova, 1966, 1967	Mn in seds; Northern Seas
Greenslate, 1973	Sed chem and Fe-Mn nodds; relation of
Greenslate, Frazer, and Arrhenius, 1974	Transition elements in seabed; origin and deposition
Hanor and Brass, 1969	Ba content in sed cores; stratigraphic variation; East Pacific Rise
Haskin and Gehl, 1962	REE distrib in seds
Haskin, Frey, <u>et al.</u> , 1966	REE in nodds, seds, and sea water
Herman, <u>et al.</u> , 1971	Fe and Mn oxides in seds; paleo-oceanographic history of Arctic

Hewett, 1932	Mn in sed
Heye, 1969	U, Th, Ra in ocean water and deep sea sed
Hutchinson, <u>et al.</u> , 1955	Ni, Co, Cu contents of deep sea sed
Isayeva, 1971	Ti and Fe in sed; relation between; Indian Ocean
Jones, A. S. G., 1972	Geochem of shallow marine sed; bay; Wales
Klenova, 1938	Colouring of deposits; polar seas
Klenova and Pakhomova, 1940	Mn in sed; polar seas
Koczy, 1949	Th in sea-water and marine sed
Krauskopf, 1957	Separation of Mn from Fe in sed processes
Kuo and Crocket, 1973	Sources of Ir, Pd, Au in deep-sea deposits
Kurbatov, L. M. and Ermolaev, 1937	K voprosu o radioaktivnosti i khimicheskoy sostave gruntov Karskogo Morya
Laevastu and Thompson, 1956	Determination and occurrence of Ni in sea-water, marine organisms and sed
Landergren, 1964	Geochem of sed; ocean
Landergren and Joensuu, 1965	Trace element distrib in sed core; Pacific
Landergren, <u>et al.</u> , 1966	Ti, Mn, and Fe in sed; constancy and variance in distrib; ocean
Lavrov, <u>et al.</u> , 1973	U, Th, Pa in Mn nod
Manheim, 1961	Geochem profile of Baltic Sea
Mathews, A. D. and Riley, 1970	Thallium in sea water and marine sed
McMurtry, 1974	Mineralogy and geochem of sed from Nazca Plate
Michard, 1971	Model for Mn distrib in calcareous sed cores
Mo, <u>et al.</u> , 1973	Uranium in sed; marine



Muller, G., 1967	HCl-soluble Fe, Mn, and Cu of Recent seds; Indian Ocean, E coast Somalia
Mullin and Riley, 1956	Cadmium in sea water, marine organisms and seds
Murata, 1939	Exchangeable Mn in muds; river and ocean
Murata and Erd, 1964	Composition of seds from Mohole Guadalupe site
Murty, <u>et al.</u> , 1968	Mn in shelf seds; W coast India
Murty, <u>et al.</u> , 1970	Ni in marine seds; distrib of; W coast India
Nayudu, 1969	Biolithology and chem of surface seds; subantarctic Pacific
Nayudu, 1971	Lithology and chem of surface seds; subantarctic Pacific
Neveskiy and Scherbakov, 1969	Fe accum and distrib in seds; bay; White Sea
Pakhomova, 1948	Northern Russian seas; Mn in sediments
Paterson, 1967	Relation of Mn and Ni in pelagic deposits; mineralogy of seds assoc/w Mn nod
Peterson and Griffin, 1964	Volcanism and clay minerals in SE Pacific
Peterson and Robertson, 1973	Sed and Mn nod particles; adsorption of dissolved organic compounds from sea water
Petterson, 1945	Fe and Mn on ocean floor
Petterson, 1959	Mn and Ni on ocean floor
Petterson and Rotschi, 1952	Ni content of deep-sea deposits
Piper, 1971	Distrib of trace elements in seds; East Pacific Rise
Piper, 1973b	REE in sea water and marine seds; fractionation of

Piper, 1974	REE in Fe-Mn nods and other marine phases
Piper and Graef, 1974	Au and REE in seds; East Pacific Rise
Rao, <u>et al.</u> , 1970	Mn in bottom seds; E Bay of Bengal
Revelle, 1944	Marine bottom samples collected in Pacific by seventh <u>Carnegie</u> cruise
Revelle, <u>et al.</u> , 1955	Distrib and chem composition of seds; Pacific
Robertson, E. E., <u>et al.</u> , 1968	Multi-element analysis of seawater, marine organisms, and seds; neutron activation
Rotschi, 1952	Fe, Mn, and Ni in cores; ocean
Rozanov, <u>et al.</u> , 1972	Forms of Fe and Mn in seds of NW Pacific
Rydell and Bonatti, 1973	Uranium in submarine metalliferous deposits
Savin and Epstein, 1968	Oxygen and hydrogen isotope geochem of ocean seds
Savin and Epstein, 1970	Oxygen and hydrogen isotope geochem of ocean seds and shales
Scott, M. R., Osmond, and Cochran, 1972a, 1972b	Sedimentation rates and sed chem; S Indian Basin
Scott, M. R., Scott, Morse, <u>et al.</u> , 1974	Transition metals in seds adjacent to TAG hydrothermal field
Sevast'yanov, 1967	Redistrib of arsenic during formation of Fe-Mn concretions in Black Sea sed
Sevast'yanov and Volkov, 1967	Chem elements in seds; formation of Fe-Mn nods; Black Sea
Shanks and Hanor, 1972	Experimental study of Fe and Mn migration in marine seds
Skornyakova, 1965, 1966	Dispersed Fe and Mn in seds; Pacific
Skornyakova and Petelin, 1967	Seds; central South Pacific

Smales and Wiseman, 1955	Origin of Ni in deep-sea seds
Sokolova and Pilipchuk, 1973	Geochem of selenium in seds; NW Pacific
Somayajulu and Goldberg, 1966	Th and U isotopes in sea water and seds
Subba Rao, 1962	Mn in shelf seds; E coast India
Swanson, <u>et al.</u> , 1967	Geochem of deep-sea sed along 160°W meridian in north Pacific Ocean
Takeda, 1974	Investigations of deep sea mineral resources in NW Pacific
Tieh and Pyle, 1969	Distrib of trace elements in seds; Gulf of Mexico
Turekian, 1957	Significance of variations in Sr content of deep-sea cores
Turekian, 1962	Rates of accum of several trace elements in a carbonate-rich Atlantic deep-sea core
Turekian, 1965	Geochem of marine seds
Turekian, 1968	Deep-sea deposition of Ba, Co, Ag
Turekian and Imbrie, 1966	Distrib of trace elements in seds; Atlantic
Turekian and Tausch, 1964	Ba in deep-sea seds; Atlantic
Turekian and Wedepohl, 1961	Distrib of elements in some major units of earth's crust
Turner and Harriss, 1970	Distrib of Fe and Mn in cores; Kara Sea
van der Weijen, <u>et al.</u> , 1970	Geochem of seds; North Atlantic
Volkov and Fomina, 1967	REE in seds and Mn concretions of ocean
Volkov and Fomina, 1973	New data on geochem of REE in Pacific sed
Volkov and Sevastianov, 1968	Redistrib of chem elements during diagenesis; Black Sea sed
von der Borch and Rex, 1970	Amorphous Fe-oxide precipitates; sed cores; DSDP Leg 5

von der Borch, <u>et al.</u> , 1971	Fe-rich seds; cores; DSDP Leg 8
Wangersky and Joensuu, 1964	Sr, Mg, and Mn in fossil foram carbonates
Wangersky and Joensuu, 1967	Carbonate deep-sea cores; fractionation of
Watson and Angino, 1969	Fe-rich layers in seds; Gulf of Mexico
Wedepohl, 1960	Geochem of pelagic samples; trace analysis examination; Atlantic
Wildeman and Haskin, 1965	REE in ocean seds
Windom, 1971	Fe, Mn, Ni, Co in Recent seds; distrib and diagenesis; marine
Yemel'yanov and Shurko, 1973	Fe in seds; Atlantic
Zenkevitch, 1963	Seds of northern Russian seas; biology of seas of USSR

## S E C T I O N 1 1

### CHEMICAL ELEMENTS IN AQUEOUS SOLUTIONS

This section lists reports on dissolved, absorbed, and particulate chemical substances found in sea water, fresh water, or in the interstitial water of sediments and soils.

## CHEMICAL ELEMENTS IN AQUEOUS SOLUTIONS

Angino, <u>et al.</u> , 1971	Mn in water; electron spin resonance
Anikouchine, 1967	Dissolved chem substances in marine seds
Armstrong, 1957	Fe content in sea water
Arnold, 1958	Trace elements and transport rates; ocean
Atkins, 1953	Seasonal variation in Cu content of sea-water
Atkinson and Stefanson, 1969	Particulate Al and Fe in seawater off SE coast of US
Back and Barnes, 1965	Electrochem potentials and Fe content; ground water flow patterns
Barnes, I. and Clark, 1969	Chem properties of ground water; effects on wells
Baturin, 1973	Uranium in the modern marine sed cycle
Belyayev and Gordeyev, 1972	Mn, Ag, Pb, and Cd in sea water; atomic absorption
Bender, 1971	Mn in pelagic seds; upward diffusion
Bender, 1972	Trace metal removal; oceans
Benes and Garba, 1966	Mn adsorption in glass from dilute aqueous solution; radiotracer study
Berner, 1973	Phosphate removal from sea water by adsorption on volcanogenic ferric oxides
Bertine, 1970	Marine geochem of Cr and Mo
Betzer, 1971	Concentration and distrib of particulate Fe in waters of NW Atlantic and Caribbean Sea
Betzer and Pilson, 1970	Concentrations of particulate Fe in Atlantic open-ocean water

Betzer and Pilson, 1971	Particulate Fe and nepheloid layer; NW Atlantic, Caribbean and Gulf of Mexico
Betzer, <u>et al.</u> , 1974	Mid-Atlantic Ridge and its effect on the composition of particulate matter in deep ocean
Bhat, <u>et al.</u> , 1969	$^{234}\text{Th}/^{238}\text{U}$ ratios in ocean
Bischoff and Sayles, 1972	Pore fluid and mineralogical studies of recent marine sed; Bauer Depression, East Pacific Rise
Bolter, <u>et al.</u> , 1964	Rb, Cs, Ba; distrib in oceans
Bonatti, 1971	Mn fluctuations in sed cores; Caribbean
Boström, 1967a	pH-controlling redox reactions in natural waters
Bowen, 1956	Sr and Ba in sea water and marine organisms
Boyle, <u>et al.</u> , 1966	Pb, Zn, Cu, As, Sb, Mo, Sn, W, Ag, Ni, Co, Cr, Ba, and Mn in sed and sea water; geochem of; streams; New Brunswick
Brewer, 1972	Particulate Mn; Black Sea
Brewer and Spencer, 1971	Mn in anoxic waters; colorimetric determination
Brewer and Spencer, 1972	Trace element profiles from Geosecs-II test station; Sargasso Sea
Brewer, Spencer, and Bender, 1974	Elemental composition of suspended matter; N Argentine Basin
Brewer, Spencer, and Sachs, 1970	Trace metals; Black Sea
Brezonik, <u>et al.</u> , 1969	Ni and Mn; geochem of; lake; Wisconsin
Bruyevich and Kulick, 1967	Alkalinity in interstitial solutions of sed; ocean
Buckley and Cranston, 1973	Geochem interactions between water and particulate solids; models for mechanisms of metal dispersion and accum in marine environments

Burton, J. D., 1966	Problems concerning marine geochem of vanadium
Byrne and Kester, 1974	Solubility of hydrous ferric oxide in seawater
Calvert and Price, 1972	Diffusion and reaction profiles; dissolved Mn in pore waters of marine seds
Cann and Winter, 1971	Suspended sed in seawater; x-ray fluorescence
Canney, 1967	Hydrous Mn-Fe oxide scavenging; effect on stream sed surveys
Carpenter, 1969	Factors controlling marine geochem of fluorine
Carr and Gordon, 1970	Mn analysis of natural water; effect on storage
Chow, 1958	Pb isotopes in sea water and marine seds
Clark, 1924	Data of geochemistry
Cooper, 1948	Chem distrib of Fe in sea
Corliss, 1970, 1971	Origin of metal-bearing submarine hydrothermal solutions
Costabile and Perron, 1971	Diatomite filters end Mn problems
Craig, 1974	Scavenging model for trace elements in the deep sea
Crerar and Barnes, 1974	Deposition of deep-sea Mn nodds
Cross, <u>et al.</u> , 1970	Mn, Fe, and Zn in sed, water and polychaetous worms; biogeochem; coastal plain estuary
Culkin and Riley, 1958	Gallium in seawater
Debyser and Rouge, 1956	Origin of Fe; interstitial waters; marine seds
DeGroot, 1966	Trace element mobility; deltas



Delfino and Lee, 1969	Mn in lake waters; colorimetric determination
Dieulafait, 1883	Mn in seawater and lake deposits
Duchart, <u>et al.</u> , 1973	Distrib of trace metals in the pore waters of shallow marine seds; Loch Fyne
Duval and Kurbatov, 1952	Adsorption of Co and Ba ions by hydrous ferric oxide at equilibrium
Ehrlich, H., 1973b	Mn cycle in sea
Elderfield, 1972a	Water chemistry; effects of volcanism; Deception Island, Antarctica
El Wardani, 1958	Marine geochem of germanium; origin of Pacific pelagic clay minerals
Eristavi, 1948	Adsorption of Ni, Co from aqueous solutions by Mn oxides and Mn ores; Chiaturi, USSR
Ewing and Thorndike, 1964	Suspended matter in deep ocean water
Fayward, 1971	Oxidation potential and Fe in ground water; relation between in aquifer; Louisiana
Fein, <u>et al.</u> , 1974	Geochem of seawater assoc/w actively forming pillow lava; Puna-Kau, Hawaii
Ferguson, 1970	Fe and trace metals; co-precipitation from aqueous solutions
Firth, 1969	Mn nodds; sed and seawater; mineralogy and chem of; survey sampling techniques; economic potential; Pacific and worldwide
Fluorie, 1972	Particulate Mn in sea water; marine anoxic basins
Fox, R. F., <u>et al.</u> , 1941	Equilibria of Mn hydroxide, Mn (OH) <sub>2</sub> , in hydrochloric acid and sodium hydroxide
Fukai, 1968	Co in seawater with solid Mn dioxide; spectrophotometric determination

Fukai, <u>et al.</u> , 1966	Co in seawater with solid Mn dioxide
Geloso, 1927	Adsorption by colloidal MnO <sub>2</sub>
Glagoleva, 1959	Formy migratsii elementov v rechnykh vodakh
Goldberg, 1961a	Chem in oceans
Goldberg, 1963a	Oceans as chem system
Goldberg, 1965	Minor elements in seawater
Goto, <u>et al.</u> , 1962	Mn in waters containing Fe; rapid colorimetric determination
Graham, 1959	Metabolically induced precipitation of trace elements from seawater
Grass, 1969	Tile clogging by Fe and Mn; Imperial Valley, Calif
Greenhaigh and Riley, 1963	Occurrence of abnormally high fluoride concentrations at depth in oceans
Griel, 1952	Ti in seawater
Griffin, 1960	Significance and removal of Mn in water supplies
Groot and Ewing, 1963	Suspended clay in water sample from deep ocean
Handa, 1969	Mn in natural waters; chem of
Hart, R. A., 1970	Chem exchange between seawater and deep ocean basalts
Hart, R. A., 1973	Model for chem exchange in basalt-seawater system; oceanic layer II
Hartmann, 1964	Mn and Fe; geochem of; Baltic Sea
Harvey, 1937	Colloidal ferric hydroxide in seawater
Harvey, 1949	Mn in fresh and seawater
Haskin, <u>et al.</u> , 1966	REE in Mn nod, sed, and seawater
Head, 1971	Fe in seawater; Southampton, UK

Hem, 1963	Chem equilibria and Mn oxidation rates
Hem, 1964	Mn oxides; deposition and solution of
Hem, 1972	Availability of Fe and Mn in aqueous systems; influence of chem factors
Hem and Cropper, 1959	Survey of ferrous-ferric chem equilibria and redox potentials
Hem and Skougstad, 1960	Coprecipitation effects in solutions containing ferrous, ferric and cupric ions
Henriksen, 1966	Mn in water containing Fe; formaldoxime method
Heye, 1969	U, Th, Ra in ocean water and deep sea sed
Horne, 1969	Structure of water and chem of hydrosphere
Horsnail, <u>et al.</u> , 1969	Metal content of drainage sed; environmental influences
Hunt, A. S. and Henson, 1969	Recent sedimentation and water properties; Lake Champlain
Ingols and Wilroy, 1962	Mn in water; Georgia
Ishibashi, <u>et al.</u> , 1956	Content of Be in sea-water
Ishibashi, <u>et al.</u> , 1960	Mn in seawater
Jenkins, 1970	Colloid chem of hydrous MnO <sub>2</sub> ; relation to Mn removal
Jenne, 1968	Role of hydrous Mn and Fe oxides; soils and water
Joyner, 1964	Determination of particulate Fe and Al; coastal water of Pacific NW
Joyner and Finley, 1966	Mn and Fe in seawater
Kaneshima and Yonehara, 1970	Fe and Mn in particulate matter in surface water; Antarctic Ocean
Kester and Byrne, 1972	Fe in seawater

- Kharkar, et al., 1968a Transport of nuclides to the sea by streams and its bearing on determining sites of removal
- Kharkar, et al., 1968b Dissolved Ag, Mo, Sb, Se, Cr, Co, Rb, and Cs; stream to ocean
- Koczy, 1949 Th in sea-water and marine seds
- Koide and Goldberg, 1965  $U^{234}/U^{238}$  ratios in seawater.
- Krauskopf, 1956 Rare elements in seawater
- Krishnaswamy and Lal, 1972 Mn nodes and budget of trace solubles; oceans
- Kurbatov, M. H., et al., 1951 Isothermal adsorption of Co from dilute solutions
- Laevastu and Thompson, 1956 Determination and occurrence of Ni; sea-water, marine organisms and seds
- Lahermo, 1971a Chem denudation by ground water; Finnish Lapland
- Lahermo, 1971b Hydrogeology of coastal region; SE Finland
- Langmuir, 1969b Fe in groundwater; geochem of; coastal plain; New Jersey
- Langmuir and Whittemore, 1971 Precipitated ferric oxyhydroxides; stability variations of
- Lawrence and Taylor, 1971 Clay minerals and hydroxides in soils compared to meteoric waters; deuterium and oxygen-18 correlation
- Lee and Harlin, 1965 Water quality; effect of intake location
- Lewis and Goldberg, 1954 Fe in marine waters
- Li, Ku, et al., 1973 Ba in Antarctic Ocean; implications regarding marine geochem of Ba and  $^{226}\text{Ra}$
- Lighthart, 1963 Sulfate-reducing bacteria; reservoir; S Calif
- Lisitsin, 1961 Raspredelenie i sostav vsveshchennogo materiale v moryakh i okeanokh: Sovremennye osadki morei i okeanov

Lisitsin, 1964	Raspredelenie i khimicheskii sostav vsvesi v vodskh Indiiskogo okeana
Livingstone, 1963	Chem composition of rivers and lakes
Lohammar, 1938	Water chem and higher vegetation of Swedish lakes
Loveridge, <u>et al.</u> , 1960	Cu, Cr, Pb, and Mn in seawater
MacDougall and Harriss, 1969	Geochem of watershed; Arctic
Mai-thi and Ponnamparuma, 1966	Ca carbonate, Mn dioxide, Fe hydroxide and flooding; rice growth in soil
Manheim, 1961	Geochem profile of Baltic
Mathews, A. D. and Riley, 1970	Thallium in seawater and marine sed
Matsumoto, 1970	Mn micrograins in seawater
McMahon, 1969	Acid-soluble and total Fe; distrib of; small lake
Michard, 1967a	Redox potential of natural waters; use of Eh-pH diagrams
Michard, 1967b	Redox potential of natural waters; use of Eh-pH diagrams; reply to remarks
Miller, <u>et al.</u> , 1966	Hot brines and recent Fe deposits; Red Sea
Mokyevskaia, 1961	Mn in waters of Black Sea
Mokyevskaia, 1966	Mn in water of Pacific
Moore, W. S., 1969	Oceanic concentrations of Ra <sup>228</sup>
Moore, W. S. and Sackett, 1964	U and Th series inequilibrium in seawater
Moore, W. S., <u>et al.</u> , 1973	Trace element extraction from natural waters using Mn-impregnated fibers
Morgan, J. J., 1967a	Chem thermodynamics in natural water systems
Morgan, J. J., 1967b	Mn in natural waters; chem equilibrium and kinetic properties of

Morgan, J. J. and Stumm, 1964a	Colloid-chemical properties of MnO <sub>2</sub>
Morgan, J. J. and Stumm, 1964b	Multivalent metal oxides in limnological transformations; Fe and Mn
Morgan, J. J. and Stumm, 1965	Aqueous Mn; chem of
Mortimer, 1941	Dissolved substance exchange: mud to water; lakes
Mortimer, 1942	Dissolved substance exchange: mud to water; lakes
Mortimer, 1971	Chem exchange: sed to water; Great Lakes
Mottl, <u>et al.</u> , 1974	Chem exchange between sea water and MORB during hydrothermal alteration; experimental study
Mottola and Harrison, 1971	Mn (II) determination in solution; kinetic methods
Moussard, <u>et al.</u> , 1966	Electrochem equilibria in aqueous solution
Mullin and Riley, 1956	Cd in seawater, marine organisms, and sed
Murata, 1939	Exchangeable Mn in muds; river and ocean
Murray, D. J., <u>et al.</u> , 1968	Adsorption of aqueous metal on colloidal hydrous Mn oxide
Murray, J. W., 1969	Oxidation and reduction reactions in seawater
Murray, J. W., 1970a	Surface chem of hydrous Fe and Mn oxides; chem oceanography
Murray, J. W., 1970b	Fe and Mn hydrous oxide surface chem; chem oceanography
Nesterova, 1960	Chem composition of suspended and dissolved loads of Ob River
O'Connor, 1971	Fe and Mn; public water supplies
Parker, 1962	Co, Fe, and Mn in bay; Texas

Parker, <u>et al.</u> , 1963	Co, Fe, and Mn in bay, Texas
Patrick and Turner, 1968	Mn transformation in water-logged soil; effect of redox potential
Perrin, 1962	Hydrolysis of manganous (II) ion
Peterson and Robertson, 1973	Dissolved organic compounds from seawater; adsorption by sed and Mn nod particles; ocean
Piper, 1973b	REE in seawater and marine sed; fractionization of
Plank, <u>et al.</u> , 1972	Light scattering and suspended matter in nepheloid layers
Ponnamperuma, Loy, and Tianco, 1969	Redox equilibria in flooded soils; Mn oxide systems
Ponnamperuma, Tianco, and Loy, 1967	Redox equilibria in flooded soils; Fe hydroxide systems
Poon and De Luise, 1967	Mn cycle in impoundment water
Presley and Kaplan, 1972	Interstitial water chem
Presley, <u>et al.</u> , 1967	Mn and elements in sed interstitial water; marine
Preston, <u>et al.</u> , 1972	Heavy metals in seawater, suspended matter and biological indicators; coastal British Isles
Price, 1973	Chem of particulate matter in water; Cariaco trench; Venezuela
Pronina, <u>et al.</u> , 1974	Uptake of biogenic forms of Ni and Co from sea water by natural hydroxides of Fe and Mn
Pushkina, 1967	Fe, Mn, Si, P, B, and Al in seawater; Santorini Volcano
Reid, <u>et al.</u> , 1974	Radium extraction from sea water; efficiency of Mn-impregnated acrylic fibers
Rickard, 1970	Cu in natural aqueous solutions; chem of

Riley and Skirrow, 1968a,b	Chem oceanography
Riley and Taylor, 1968	Mn in seawater
Riley and Taylor, 1972	Cd, Cu, Fe, Mn, Mo, Ni, V, and Zn in water; tropical NE Atlantic
Robertson, 1970	Co in water; distrib of; ocean
Robertson and Rancitelli, 1973	Trace elements to seawater resulting from contact with Fe-Mn nodds; ocean
Robertson, <u>et al.</u> , 1968	Elements of seawater, marine organisms, and sed; neutron activation
Rona, Akers, <u>et al.</u> , 1959	Mn in seawater; distrib of
Rona, Hood, <u>et al.</u> , 1962	Mn and Zn in seawater; activation analysis
Rydell, <u>et al.</u> , 1974	Postdepositional injections of uranium-rich solutions into East Pacific Rise sed
Sapozhnikov, 1970	Accum of Mn in seawater; genesis of Mn deposits
Savage, 1936	Mn; solution, transport, and precipitation of
Schutz and Turekian, 1965a	Co, Ni, and Ag in ocean water; distrib of; Pacific-Antarctic
Schutz and Turekian, 1965b	Trace elements in seawater; distrib of; neutron activation
Scott, M. R., Scott, Nalwalk, <u>et al.</u> , 1973	Hydrothermal Mn; median valley, Mid-Atlantic Ridge
Seiwell, 1935	Fe analyses of Atlantic coastal waters
Serdobol'skii and Sinyagina, 1953	Base-acid conditions for formation of soluble organic compounds of Mn
Shanks and Hanor, 1972	Experimental study of Fe and Mn migration in marine sed
Sillen, 1961	Physical chem of seawater



Simons, L. H., <u>et al.</u> , 1953	Al and Fe in Atlantic and Gulf of Mexico waters
Slowey and Hood, 1971	Cu, Mn and Zn in water; Gulf of Mexico
Somayajulu and Church, 1973	Ra, Th, U isotopes in interstitial water; Pacific sed
Somayajulu and Goldberg, 1966	Th and U isotopes in sea water and seds
Spencer and Brewer, 1969	Distrib of Cu, Zn, Ni in sea water; Gulf of Maine and the Sargasso
Spencer and Brewer, 1971	Black Sea; distrib of Mn and trace metals in water
Spencer, <u>et al.</u> , 1972	Black Sea; distrib and trace element composition of suspended matter
Stumm and Lee, 1960	Aqueous Fe; chem of
Stumm and Morgan, 1970	Chem equilibrium in natural waters
Tageeva and Tikhomirova, 1962	Geochem of pore solutions in diagenesis of marine seds
Tanaka, 1964	Mn dioxide in lake water
Taylor, P. S. and Stoiber, 1971	Soluble material on ash from Central American volcanoes
Theobald, <u>et al.</u> , 1963	Al, Fe, and Mn; precipitation of; rivers; Colorado
Thompson and Bremner, 1935	Occurrence of Fe in waters of NE Pacific
Thompson and Wilson, 1935	Mn in seawater
Tooms, 1970	Metalliferous brines and related deposits
Turekian, 1964	Sr; geochem of; marine
Turekina and Johnson, 1966	Ba distrib in seawater
Turekian and Kharkar, 1967	Trace metal supply to and distrib in oceans

Turekian and Schutz, 1965	Trace element economy in the oceans
Tzur, 1971	Interstitial diffusion and advection of solute in sed
Varentsov, 1970a,b	Mn leaching; volcanic materials in seawater
Varentsov and Pronina, 1972	Sorption by Fe-Mn oxides from seawater
Varentsov and Pronina, 1973	Mechanism of Fe-Mn ore formation; recent basins; experimental data on Ni and Co
Varentsov and Stepanets, 1970	Leaching of Mn by seawater from mafic volcanic materials
Vikhrenko, 1967	Fe and Mn in surface layers; distrib of; Atlantic
Vinogradova, <u>et al.</u> , 1972	Vertical distrib of dissolved trace elements; Black Sea
Vogt, J. H. L., 1906	Manganese-like metals; behavior toward Fe and Mn in ocean and trace-metal ores
Volkov, Sokolova, <u>et al.</u> , 1973	Mo in water; Atlantic and Mediterranean
Wangersky and Gordon, 1965	Particulate C, organic C, and Mn <sup>++</sup> in ocean
Wangersky and Hutchinson, 1958	Mn deposits and deep water movements; Caribbean
Weber and Schenk, 1968	Chem interaction of dissolved silica with Fe(II) and (III)
Weiler, 1973	Interstitial water composition in sed; western Lake Ontario
Wittemore and Langmuir, 1973	Stability of ferric oxyhydroxides in natural waters
Wiebe, 1930	Mn in water; Mississippi River, Iowa
Wiedman and Fetner, 1957	Mn in reservoirs; anaerobic reduction of
Wilkniss, Carr, and Hoover, 1970	Submarine volcanism and chem changes in seawater

- Wilkniss, Warner, and Carr, 1971 F, Fe, and Mn; geochem of; coastal waters and fresh-water springs, Hawaii
- Wilska, 1952 Trace elements in Finnish ground and mine waters
- Yatsimirskiy, et al., 1971 Mn and Cu in marine suspension; Baltic and Atlantic
- Yemel'yanov and Vlasenko, 1972 Concentrations of dissolved forms of Fe, Mn, Cu in marine and pore waters; Atlantic
- Yemel'yanov, et al., 1971 Determination of traces of Fe, Co, Ti in sea water and suspended matter; Baltic and Atlantic
- Zelenov, 1964 Fe and Mn in exhalations of submarine volcano; Indonesia
- Zies, 1929 Acid gases contributed to sea during volcanic activity; Valley of Ten Thousand Smokes, Alaska



S E C T I O N 1 2

DISTRIBUTION, MINERALOGY AND PHYSICAL PROPERTIES  
OF SEDIMENTS ASSOCIATED WITH MANGANESE DEPOSITS

This section lists publications dealing with the distribution, mineralogy and physical properties of sediments associated with ferromanganese deposits.

DISTRIBUTION, MINERALOGY AND PHYSICAL PROPERTIES OF SEDIMENTS ASSOCIATED  
WITH MANGANESE DEPOSITS

Arrhenius, 1963	Pelagic seds
Arrhenius, 1967	Deep-sea sedimentation
Bartlett and Greggs, 1969	Carbonate seds; North Atlantic
Bartlett and Greggs, 1970a	Carbonate lithification; Mid-Atlantic Ridge - 45°N
Bartlett and Greggs, 1970b	Styolitic solution surfaces; Mid-Atlantic Ridge, San Pablo Seamount
Bertine, 1974	Origin of Lau Basin Rise sed
Bezrukov, 1960	Sedimentation; NW Pacific
Bezrukov, 1972	Sedimentation; northern South Pacific
Bischoff and Sayles, 1972	Pore fluid and mineralogical studies of Recent marine seds; Bauer Depression, East Pacific Rise
Blissenbach, 1972	Continental drift and metalliferous seds
Bonatti, 1966	Volcanogenous minerals in pelagic seds; Pacific
Bonatti, Fisher, <u>et al.</u> , 1971	Mobility of transition elements, P, U, and Th in seds; ocean
Borchert, 1965	Formation of sed Fe ores; marine
Boström, 1970a	Deposition of Mn-rich seds; glacial periods
Boström, 1970e	Origin of Fe-rich seds; East Pacific Rise
Boström, 1970f	Origin of Mn-rich layers in seds; Arctic
Boström and Peterson, 1969	Origin of Al-poor Fe-Mn seds; high heat flow areas; East Pacific Rise
Boström, Peterson, <u>et al.</u> , 1969	Al-poor Fe-Mn seds; active oceanic ridges

Bowles, <u>et al.</u> , 1969	Precipitation of palygorskite and sepiolite; ocean
Bramlette, <u>et al.</u> , 1959	Sed deposition; Eniwetok Atoll
Chaynikov, 1969	Source of Mn in seds; Pacific
Ewing, Eittreim, <u>et al.</u> , 1969	Sed distribution; Indian Ocean
Firth, 1969	Mineralogy and chem of Mn nodds, sedds, and seawater; marine; worldwide
Fischer and Garrison, 1967	Carbonate lithification on sea floor; limestones dredged off Barbados
Fox, P. J. and Heezen, 1965	Sands of Mid-Atlantic Ridge
Garrety, 1970	Magnetic minerals in pelagic sedds
Gieskes, <u>et al.</u> , 1974	Geochem evidence for extensive diagenesis in DSDP Hole 245
Goldberg, 1961b	Chem and mineralogy of sedds; ocean
Goldberg, 1963b	Mineralogy and chem of sedimentation; marine
Goodell, 1965a	Sedimentary geology of the Scotia Sea and Ridge and its bearing on the Pleistocene
Gorshkova, 1931	Chem and mineralogy of sedds; Barents and White Seas
Gorshkova, 1957	Seds; Kara Sea
Gorshkova, 1960	Seds; Norwegian Sea
Gorshkova, 1966	Mn in sedds; Northern Seas
Gorshkova, 1967	Mn in bottom sedds; Northern Seas
Gripenberg, 1934	Seds; North Baltic
Hammond, 1968	Fe and Mn in sedds
Hartmann, <u>et al.</u> , 1973	Geochem and soil-mechanical study; sedds; Pacific
Hewett, 1932	Mn in sedds

Horn, D. R., Horn, and Delach, 1973b	Cu and Ni content of ocean Fe-Mn deposits; relation to substrate properties
Kolpack, 1967	Surface seds; Drake Passage
Koster, 1966	Recent seds and sed history; Pacific- Antarctic Ridge
Lisitsyn, 1972	Sedimentation in world ocean
Logvinenko, <u>et al.</u> , 1972	Rhodocrosite in deep sea seds; Pacific
Lonsdale, Normark, and Neumann, 1972	Sedimentation and erosion, Horizon Guyot
Loring and Nota, 1968	Fe, Mn, Ti in glacial marine seds; estuary of St Lawrence River, Canada
Macdonald, R. D. and Murray, 1973	Sedimentation and Mn concretions; British Columbia fiord (Jervis Inlet)
Margolis, 1973	Mn deposits; DSDP Leg 29; subantarctic
McMurtry, 1974	Mineralogy and geochem of seds; Nazca Plate
Meyer, 1973a,b	Surface sed and Mn nod facies; NE Equat Pacific; <u>Valdivia</u> cruises 1972/73
Monney, 1971	Engineering properties of marine seds
Moore, T. C., 1970	Sed and stratigraphy; abyssal hills; central Equat Pacific
Moore, T. C. and Heath, 1966	Mn nods, topography and thickness of Quaternary seds; central Pacific
Morgenstein, 1967	Authigenic cementation of scoriaceous sed; ocean; west of Society Ridge, South Pacific
Morgenstein, 1969	Palagonite in sed; Atlantic and Pacific
Morgenstein, 1972b	Sideromelane-palagonite transition in marine seds
Morgenstein, 1972c	Sed diagenesis and Mn accretion rates; Waho Shelf, Hawaii



Mullen, <u>et al.</u> , 1972	Atmospheric dust and ice rafting; significance for Arctic Ocean sed
Murata and Erd, 1964	Composition of sed; Mohole Guadalupe site
Paterson, 1967	Mineralogy of Mn nod sed; Mn:Ni in pelagic deposits
Payne, <u>et al.</u> , 1972	Turbidite muds with diatom ooze; Pleistocene sed variation defined by closely spaced cores; off Antarctica
Peterson and Goldberg, 1962	Feldspar distrib; South Pacific pelagic sed
Revelle, <u>et al.</u> , 1955	Pelagic sed of Pacific
Samoilov and Gorshkova, 1924	Seds of Barents and Kara Seas
Stetson, Uchupi, and Milliman, 1969	Surface and subsurface morphology of two small areas of Blake Plateau
Takeda, 1974	Investigations of deep sea mineral resources; NW Pacific
Zelenov, 1963	Formation of sed; role of underwater vulcanism
Zen, 1959	Mineralogy and petrography of sed; marine; off coast Peru and Chile



S E C T I O N 1 3

PETROLOGY AND CHEMISTRY OF ROCKS ASSOCIATED WITH MANGANESE DEPOSITS

This section lists reports on the petrology and chemistry of rocks, mostly submarine basalts, associated with manganese deposits.

PETROLOGY AND CHEMISTRY OF ROCKS ASSOCIATED WITH MANGANESE DEPOSITS

Anonymous, 1971i	Dredged basalt; W coast Mexico
Cann, 1970	Petrol of basalts; dredged; Gulf of Aden
Cann and Vine, 1966	Petrol and magnetic survey; Carlsberg Ridge
Corliss, 1970	MORB: origin of submarine hydrothermal solutions; regional diversity along Mid-Atlantic Ridge
Feden, 1966	Volcanic rock; Caryn Seamount
Fisher, R. L. and Engel, 1969	Ultramafic and basaltic rocks; dredged; Tonga Trench
Hamilton and Rex, 1959	Lower Eocene phosphatized Globigerina ooze; Sylvania Guyot
Hanor and Drever, 1971	Vein Mn; ocean
Hart, R. A., 1970	Chem exchange; sea water and basalt; ocean
Hart, S. R., <u>et al.</u> , 1972	Basalts and sea floor spreading; Mariana Island Arc
Henderson and Dale, 1970	Transition element ions; olivine and oceanic basalts
Krause and Schilling, 1969	Dredged basalt; Reykjanes Ridge, North Atlantic
Lahiri, 1971	Mineralogy and genesis of Mn oxides and silicate rocks; Madhya Pradesh, India
Mathews, D. H., 1961	Lavas from abyssal hill; North Atlantic
Mathews, D. H., 1962	Altered lavas; NE Atlantic
Mathews, D. H., 1971	Altered basalts; Swallow Bank, NE Atlantic
Moore, J. G., 1965	Petrol of deep-sea basalt; near Hawaii

Moore, J. G., 1966	Submarine basalt; Hawaii; palagonitization rate
Moore, J. G., 1970	Submarine basalt; Revillagigedo Islands, Mexico
Murdmaa, <u>et al.</u> , 1972	Volcanogenous clastic rocks; Pacific
Nayudu, 1965a	Petrology of volcanics and seds; Mendocino Fracture Zone
Paster, 1968, 1971	Submarine basalt pillows, petrol variations; South Pacific-Antarctic Ocean
Pratt, 1971	Lithology of rocks; dredged; Blake Plateau
Sokolova, E. I., 1964	Physiochem; sed Fe and Mn, assoc rocks
Watkins and Self, 1971	<u>Eltanin</u> rocks; dredged; Scotia Sea
Wiseman, 1937	Geology and mineralogy; basalts; Carlsberg Ridge, Indian Ocean



## S E C T I O N 1 4

### a - MINERALOGY OF MANGANESE NODULES

This section lists reports containing information on the ferromanganese and/or non-ferromanganese mineralogy of manganese nodules, including minerals whose presence in nodules has not been confirmed.

### b - MANGANESE MINERALS

This section lists reports containing information on the mineralogy of terrestrial manganese deposits, as well as on the nature of synthetic manganese minerals.

## MINERALOGY OF MANGANESE NODULES

- |  |  |
|--|--|
| Andrushchenko and Skornyakova,<br>1969 | Texture and mineral composition of<br>Fe-Mn concretions; South Pacific                         |
| Arrhenius, 1963                        | Pelagic seds   |
| Arrhenius, Mero, and Korkisch,<br>1964 | Origin of Mn minerals; ocean   |
| Barnes, S. S., 1967a                   | Mineralogy and chem of Fe-Mn nods  |
| Barnes, S. S., 1967b                   | Formation of Fe-Mn nods; ocean   |
| Barnes, S. S., 1967c                   | Minor elements; Fe-Mn nods   |
| Brown, B. A., 1971                     | Geochem of inter-element relations of<br>Mn nods; ocean  |
| Burns, R. G., 1965                     | Formation of Co (III) in amorphous<br>$\text{FeOOH}\cdot n\text{H}_2\text{O}$ phase of Mn nods |
| Burns, R. G. and Brown, 1972           | Nucleation and mineralogical controls<br>on composition of Mn nods; ocean                      |
| Burns, R. G. and Fuerstenau,<br>1966   | Elements in Mn nods; electron-probe  |
| Burns, R. G., <u>et al.</u> , 1974     | Fe-Mn nod mineralogy: suggested<br>terminology of principal Mn oxide<br>phases                 |
| Buser, 1959                            | Fe and Mn compounds in Mn nods   |
| Buser and Grutter, 1956                | Nature of Mn nods  |
| Carr, 1970                             | Minerals in Mn nods; marine  |
| Crerar and Barnes, 1974                | Deposition of deep-sea Mn nods   |
| Cronan, 1969b                          | Chem and mineralogy of Mn nods;<br>variations with depth                                       |
| Cronan, 1974                           | Authigenic minerals in deep-sea seds   |
| Cronan and Tooms, 1969                 | Geochem of Mn nods and assoc pelagic<br>sed; Pacific and Indian Oceans                         |



- Dunham and Glasby, 1974 Petrographic and electron microprobe investigation of some deep- and shallow-water Mn nodds
- Frazer, F. W. and Ostwald, 1970 Deep-sea Mn nodds; chem and mineralogical investigations
- Glasby, 1972f Mineralogy of Mn nodds; marine
- Goodell, et al., 1971 Fe-Mn deposits of South Pacific, Drake Passage, Scotia Sea
- Grant, 1967 Chem, mineralogy, distrib and physical aspects of Mn nodds; Southern Oceans
- Grill, et al., 1968a Todorokite in Mn nodds; fjord, British Columbia
- Manheim, 1965b Mn-Fe accumulations; shallow marine
- McFarlin, 1967 Aragonite in Mn nodds; marine
- Meylan, 1968a Mineralogy of Fe-Mn concretions; Southern Ocean
- Meylan, 1968b Mineralogy and geochem of Mn nodds; Southern Ocean
- Meylan and Goodell, 1968 Mineralogy of Mn nodds; Southern Ocean
- Nohara, 1972 Mn minerals in Fe-Mn nodds dredged from Pacific Ocean seamounts
- Ostwald and Frazer, 1973 Chem and mineralogical investigation on deep sea Mn nodds; Southern Ocean
- Pratt and Manheim, 1967 Relation of Mn to phosphorite concretions; Blake Plateau
- Smith, R. E., et al., 1968b Geochem and mineralogy of Fe-Mn nodds; Nares Abyssal Plain
- Sorem, 1972a,b Mineral recognition and nomenclature; marine Mn nodds
- Sorem and Foster, 1973 Mineralogical, chem, and optical study; growth and economic potential of Mn nodds; ocean

Takeda, 1974

Investigations of deep sea mineral  
resources; NW Pacific

Woo, 1973

Marine Mn micronods, pebble-sized  
nods and fresh water Mn nodules;  
scanning electron microscopy

## MANGANESE MINERALS

- Agioritis, 1969 Mn minerals; DTA and infrared spectroscopy
- Allsman, 1956 Oxidation and enrichment of Mn deposits; Butte, Montana
- Bode and Schmier, 1962 "Synthesis" of ramsdellite
- Bode, et al., 1962 Phase analysis of MnO<sub>2</sub>
- Bricker, 1965 System Mn-O<sub>2</sub>-H<sub>2</sub>O; stability relations
- Brenet, 1954 Crystallography of Mn dioxides
- Brenet, et al., 1963 Varieties of MnO<sub>2</sub>; analytical and thermodynamic study
- Brown, F. H., et al., 1971 Birnessite on colemanite; Boron, Calif
- Buerger, 1936 Manganite, Mn(OH)O; symmetry and crystal structure
- Buser and Graf, 1955a Radiochem studies: ion- and isotope-exchange reactions of MnO<sub>2</sub> and manganites
- Buser and Graf, 1955b Differentiation of manganous manganite and δ-MnO<sub>2</sub> by surface measurements
- Buser, et al., 1954 Manganous manganite and δ-MnO<sub>2</sub>
- Butler and Thirsk, 1952 Cryptomelane modification of MnO<sub>2</sub> prepared in absence of potassium; electron diffraction evidence for existence and fine structure
- Byström, A. and A. M. Byström, 1950 Crystal structure of hollandite, related Mn oxide minerals and α-MnO<sub>2</sub>
- Byström, A. and A. M. Byström, 1951 Hollandite; positions of barium atoms
- Byström, A. M., 1949 Ramsdellite, an orthorhombic modification of MnO<sub>2</sub>; crystal structure

Caillère and Kraut, 1954	Thermal behavior of some manganiferous minerals
Champness, 1971	Transformation manganite → pyrolusite
Cole, <u>et al.</u> , 1947	MnO <sub>2</sub> ; x-ray diffraction study
Collins and Lipscomb, 1949	Crystal structure of groutite
Dachs, 1962	Manganite, MnOOH; determination of hydrogen positions; neutron diffraction
Dachs, 1963	Manganite; neutron and x-ray studies
Delano, 1950	Mn dioxides: classification
Dent Glasser, and Ingram, 1968	Refinement of crystal structure of groutite
deWolff, 1959	γ-MnO <sub>2</sub> diffraction patterns; interpretation
Drotschmann, 1960	Lower Mn oxides; properties
Dubois, 1936	Contribution to study of Mn oxides
Faulring, 1962	Study of Cuban todorokite; x-ray analysis
Faulring, 1965	Nsutite; unit cell determination and thermal transformations
Faulring, <u>et al.</u> , 1960	Cryptomelane; thermal transformations and properties
Feitknecht and Marti, 1945b	Manganite and artificial Mn dioxide
Feitknecht, Oswald, and Feitknecht-Steinmann, 1960	Topochemical single phase reduction of γ-MnO <sub>2</sub>
Fleischer, 1960	Studies of Mn oxide minerals; psilomelane
Fleischer and Wallace, 1943	Mn oxide minerals; preliminary report
Fleischer, <u>et al.</u> , 1962	Studies of Mn oxides; ramsdellite, an orthorhombic dimorph of pyrolusite
Frondel, 1953	New Mn oxides; hydrohausmannite and woodruffite

Fron del, <u>et al.</u> , 1960a	Birnessite and hollandite; new data
Fron del, <u>et al.</u> , 1960b	Todorokite; new occurrence
Gattow and Glemser, 1961a	Preparation and properties of MnO <sub>2</sub> : the γ- and η- groups
Gattow and Glemser, 1961b	Preparation, properties and conversions of MnO <sub>2</sub> : the ε-, β-, and α- groups
Giovanoli, 1969	Polymorphism in the Mn dioxides; a simplified scheme
Giovanoli and Leuenberger, 1969	Oxidation of Mn oxide-hydroxides
Giovanoli and Stähli, 1970	Mn (III, IV) oxides and oxyhydroxides
Giovanoli, Bernard, and Feitknecht, 1968	One- and 2-phase reduction of γ-MnO <sub>2</sub> by cinnamic alcohol
Giovanoli, Bühler and Sokolowska, 1973	Synthetic lithiophorite; electron microscopy and x-ray diffraction
Giovanoli, Bürki, and Schiess, 1973	Investigation of Mn nodds
Giovanoli, Maurer, and Feitknecht, 1967	Structure of γ-MnO <sub>2</sub>
Giovanoli, Stähli, and Feitknecht, 1969	Structure and reactivity of Mn (IV) oxides
Giovanoli, Stähli, and Feitknecht, 1970a	Oxyhydroxides of 4-valent Mn with layer lattices: Na manganese (II,III) manganate (IV)
Giovanoli, Stähli, and Feitknecht, 1970b	Oxyhydroxides of 4-valent Mn with layer lattices: manganese (III)- manganate (IV)
Giovanoli, Stähli, and Feitknecht, 1971	Oxyhydroxides of 4-valent Mn with layer lattices: reduction of Mn (III) manganate (IV) with cinnamic alcohol
Glemser, 1939	Pure synthetic braunstein
Glemser and Meisiek, 1957	Pure synthetic MnO <sub>2</sub>
Glemser, <u>et al.</u> , 1961	Preparation and properties of MnO <sub>2</sub> : the δ-group

Gruner, 1947	Groutite, $\text{HMnO}_2$ , a new mineral of the diaspore-goethite group
Gunn and Sorem, 1965	Todorokite and rancieite; near Enterprise, Oregon
Hanor and Drever, 1971	Birnessite vein filling; Marianas Trough
Hariya, 1961	Todorokite and birnessite from the Todoroki mine, Hokkaido; mineralogical studies
Hariya, 1963	Note on ishiganeite and yokosukaite
Hewett, 1964	Veins of hypogene Mn oxide; SW United States
Hewett, 1972	Manganite, hausmannite, braunite; features and origin
Hildebrand, 1974	Birnessite in large spherulite in obsidian; near Silver Cliff, Colorado
Jones, L. H. P. and Milne, 1956	Birnessite; Scotland
Kedesdy, <u>et al.</u> , 1957	Structural relationship between ramsdellite and some synthetic Mn oxides
Kondrashev and Zaslavskii, 1951	Mn dioxide; structural modification
Kulp and Perfetti, 1950	Mn oxide minerals; thermal study
Larson, 1962a	Geology and mineralogy of certain Mn oxide deposits; Philipsburg, Montana
Larson, 1962b	Zn-bearing todorokite from Philipsburg, Montana
Larson, 1964	Geology and mineralogy of Mn oxide deposits
Larson, 1969	Co- and Ni-bearing Mn oxides; Fort Payne Formation, Tennessee
Lee, D. E., 1955	Mineralogy of some Japanese Mn ores
Levinson, 1960	Todorokite; second occurrence
Levinson, 1962	Birnessite; Mexico

Ljunggren, 1955b	Mn and Fe bog ores; Sweden; DTA and x-ray examination
Ljunggren, 1970	Todorokite and pyrolusite; Sweden
Mathieson and Wadsley, 1950	Crystal structure of cryptomelane
McKenzie, 1971	Synthesis of birnessite, cryptomelane, and other oxides and hydroxides of Mn
McMurdie and Golovato, 1948	Modifications of MnO <sub>2</sub>
Meldau, <u>et al.</u> , 1973	Crystal chem of feitknechtite, β-MnOOH
Moore, G. W. and Nicholas, 1964	Speleology; birnessite on limestone cave walls
Moore, T. E., <u>et al.</u> , 1950	Solid oxides and hydroxides of Mn
Mukherjee, 1959a	Psilomelane and cryptomelane; x-ray study
Mukherjee, 1959b	X-ray study of Mn minerals
Murata and Erd, 1964	Sed composition; Mohole, Guadalupe Site
Naganna and Bouška, 1963	Woodruffite; x-ray study; Sandur ore deposits, Mysore State, India
Nambu and Tanida, 1961	Progressive alteration of MnO <sub>2</sub> observed at Toyoguchi mine, Iwate Prefecture (Japan)
Nambu, <u>et al.</u> , 1964	Todorokite; chem composition
Nye, <u>et al.</u> , 1959	Structure and morphology of MnO <sub>2</sub>
Oswald and Wampetich, 1967	Crystal structure of Mn <sub>5</sub> O <sub>8</sub> and Cd <sub>2</sub> Mn <sub>3</sub> O <sub>8</sub>
Perseil, 1966	Todorokite in marbled limestone from upper Devonian of Las Cabesses (Ariège)
Perseil, 1967	New data on rancieite from Rancie
Radtko, <u>et al.</u> , 1967	Aurorite, argentian todorokite, and hydrous Ag-bearing Pb-Mn oxide
Ramdohr and Frenzel, 1956	Mn ores

Ramsdell, 1932	Psilomelane and wad; x-ray study
Ramsdell, 1942	Unit cell of cryptomelane
Richmond and Fleischer, 1942	Cryptomelane: new name for commonest of psilomelane minerals
Roy, 1968	Mineralogy of Mn deposits
Schröder, 1952	Elemental composition and density of ramsdellite, MnO <sub>2</sub>
Schwertmann and Taylor, 1972a	Lepidocrocite to goethite; transformation
Schwertmann and Taylor, 1972b	Lepidocrocite to goethite; transformation; influence of silicate
Simons and Straczek, 1958	Geology of Mn deposits of Cuba
Smitheringale, 1929	Mn minerals; etching tests and x-ray examination
Sorem and Cameron, 1960	Mn oxides and assoc minerals; Nsuta deposits; West Africa
Sorem and Gunn, 1965	Secondary Mn oxide minerals in Washington and NE Oregon
Sorem and Gunn, 1967	Mineralogy of Mn deposits; Olympic Peninsula, Washington
Straczek, <u>et al.</u> , 1960	Mn oxides; todorokite
Taylor, R. M., <u>et al.</u> , 1964	Mineralogy and chem of Mn; Australian soils
Thiel, 1924	Mn minerals; their identification and paragenesis
Vaux, 1937	Pyrolusite (including polianite) and psilomelane; x-ray studies
Waal, 1969	Ramsdellite; mine; Cape Province, South Africa
Wadsley, 1950a	Synthesis of hydrated Mn minerals
Wadsley, 1950b	Hydrous Mn oxide with exchange properties



Wadsley, 1952	Structure of lithiophorite, (Al,Li)MnO <sub>2</sub> (OH) <sub>2</sub>
Wadsley, 1953a	Interstitial atoms in layer structure ZnMn <sub>3</sub> O <sub>7</sub> ·3H <sub>2</sub> O (chalcophanite)
Wadsley, 1953b	Crystal structure of psilomelane
Wadsley, 1955	Crystal structure of chalcophanite
Wadsley, 1964	Inorganic non-stoichiometric compounds
Wadsley and Walkley, 1951	Oxides of Mn; structure and reactivity
Wilson, M. J., <u>et al.</u> , 1970	Lithiophorites; mines; Banffshire
Yoshimura, 1934	Todorokite; mine; Hokkaido, Japan
Zotov, 1968	Present-day formation of certain Mn minerals; Mendeleev Volcano on Kunashir Island
Zwicker, <u>et al.</u> , 1962	Nsutite - a widespread Mn oxide mineral



## S E C T I O N 1 5

### GEOCHEMISTRY AND STRUCTURE OF IRON AND MANGANESE OXIDES AND HYDROXIDES

This section lists reports on the geochemistry and structure of iron and manganese oxides and hydroxides, including the topics of inter-element relationships, the incorporation of transition and minor elements, and the crystal-chemical/geochemical nature of the iron and manganese phases.

GEOCHEMISTRY AND STRUCTURE OF IRON AND MANGANESE OXIDES AND HYDROXIDES

- |                                       |   |
|---------------------------------------|---|
| Andermann, 1972a,b                    | Spectroscopic analysis of Mn nodds  |
| Anderson, B. J., <u>et al.</u> , 1973 | Sorption of silver by poorly crystallized Mn oxides                                   |
| Anonymous, 1970d                      | Silver adsorption by Mn oxides  |
| Babcan, 1960                          | Mn oxides of various valencies  |
| Barnes, S. S., 1967a                  | Mn nodds; mineralogy and chem   |
| Barnes, S. S., 1967b                  | Mn nodds; formation of; ocean   |
| Barnes, S. S., 1967c                  | Fe-Mn nodds; minor elements   |
| Benson, <u>et al.</u> , 1967          | $\gamma$ -MnO <sub>2</sub> ; potential-pH relationships                               |
| Bernal, <u>et al.</u> , 1959          | Oxides and hydroxides of Fe; structure  |
| Berner, 1973                          | Phosphate removal from sea water by adsorption on volcanogenic ferric oxides          |
| Borchert, 1970                        | Mn; ore-deposition and geochem  |
| Brenet, <u>et al.</u> , 1963          | Varieties of MnO <sub>2</sub> ; analytical study and thermodynamics                   |
| Bricker, 1965                         | System Mn-O <sub>2</sub> -H <sub>2</sub> O; stability relations                       |
| Brooks, R. R., 1965                   | Fe family elements; distrib in gleyed and concretionary material in soil; New Zealand |
| Brown, B. A., 1971                    | Mn nodds; inter-element relations; geochem of; ocean                                  |
| Burns, R. G., 1965                    | Mn nodds; cobalt (III) in amorphous FeOOH·nH <sub>2</sub> O phase                     |
| Burns, R. G. and Brown, 1972          | Mn nodds; composition; nucleation and mineralogical controls; ocean                   |
| Burns, R. G. and Fuerstenau, 1966     | Mn nodds; inter-element relations; electron-probe                                     |

- Burns, R. G. and Fyfe, 1967 Transition elements; crystal-field theory and geochem
- Burns, V. M. and Burns, 1973 Mn nod authigenesis and mechanism for nucleation and growth
- Burns, V. M. and Burns, 1974 Cobalt uptake by Fe-Mn nods, soil and Mn(IV) oxides
- Buser, 1959 Mn nods; nature of Fe and Mn compounds
- Buser and Graf, 1955a Radiochem studies; ion- and isotope-exchange reactions of MnO<sub>2</sub> and manganites
- Buser and Graf, 1955b Differentiation of manganous manganite and δ-MnO<sub>2</sub> by surface measurements
- Buser, et al., 1954 Manganous manganite and δ-MnO<sub>2</sub>
- Buser and Grutter, 1956 Mn nods; nature of
- Byström, A. and A. M. Byström, 1950 Hollandite, the related MnO<sub>2</sub> minerals and α-MnO<sub>2</sub>; crystal structure
- Caillère and Kraut, 1954 Thermal behavior of some manganiferous minerals
- Callender, 1973 Fe-Mn crusts, Mn carbonate crusts and assoc Fe-Mn nods; geochem of
- Callender, et al., 1973 Fe-Mn and carbonate crusts; geochem of; Green Bay, Lake Michigan
- Canney, 1967 Hydrous Mn-Fe oxide scavenging; effect on stream sed surveys
- Carpenter, et al., 1972 Thermomagnetic behavior of Mn nods
- Chakravarti and Dhar, 1927 Adsorption of electrolytes by MnO<sub>2</sub>; Freundlich adsorption formula
- Champness, 1971 Transformation manganite → pyrolusite
- Chukhrov, et al., 1973 Ferrihydrite (hydrous ferric oxide)
- Coey and Readman, 1973 Characterisation and magnetic properties of natural ferric gel
- Correns, 1941 Geochem of Fe and Mn

Crecelius, <u>et al.</u> , 1973	Magnetism and magnetic reversals in Fe-Mn nodds
Cronan, 1969a	Fe-Mn deposits; geochem of; ocean
Cronan, 1972b	Fe-Mn nodds; geochem of; ocean
Cronan and Thomas, 1970b, 1972	Fe-Mn oxide concretions and deposits; geochem of; Lake Ontario
Cronan and Tooms, 1967b	Mn nodds; geochem of; NW Indian Ocean
Cronan and Tooms, 1969	Mn nodds and assoc pelagic deposits; geochem of; Pacific and Indian Oceans
Dachs, 1962	Hydrogen positions in manganite; determination with neutron diffraction
Dean, <u>et al.</u> , 1974	Mn nodds; geochem and accretion rates; freshwater
Drotschmann, 1960	Properties of lower Mn oxides
Dubois, 1936	Contribution to study of Mn oxides
Duval and Kurbatov, 1952	Adsorption of Co and Ba ions by hydrous ferric oxide at equilibrium
Dyck, 1971	Silver on Fe and Mn hydrous oxides; adsorption and co-precipitation
Eristavi, 1948	Mn oxides and Mn ores; adsorption of Ni and Co from aqueous solutions
Faulring, 1965	Unit cell determination and thermal transformations of nsutite
Faulring, <u>et al.</u> , 1960	Thermal transformation and properties of cryptomelane
Feitknecht and Marti, 1945a	Oxidation of manganous hydroxide with molecular oxygen
Feitknecht, Brunner, and Oswald, 1962	Influence of moisture content on the oxidation of Mn hydroxide by molecular oxygen
Feitknecht, Oswald, and Feitknecht-Steinmann, 1960	Topochemical single phase reduction of $\gamma$ -MnO <sub>2</sub>

Feitknecht, Giovanoli, <u>et al.</u> , 1973	Hydrolysis of Fe(III) chloride by HCl-solutions
Fewkes, <u>et al.</u> , 1974	Cu-Ni rich segregations in Mn nodds; Pacific
Fox, R. F., <u>et al.</u> , 1941	Mn(OH) <sub>2</sub> equilibria in HCl and NaOH solutions
Gabano, 1967	Mn oxides; free energy of formation; determination of
Gabano, <u>et al.</u> , 1965	γ-MnO <sub>2</sub> ; surface properties
Garrels, 1960	Mineral equilibria at low temperatures and pressures
Garrels and Christ, 1965	Solutions, minerals and equilibria
Geloso, 1927	Adsorption by colloidal MnO <sub>2</sub>
Giесе, <u>et al.</u> , 1971	Electrostatic energy calculations of diaspore, goethite and groutite
Giovanoli, 1972	Characterization and phase trans- formation of amorphous ferric hydroxide; discussion of paper
Glagoleva, 1971	Fe-Mn nodds in sedds; chem of; NW Pacific
Glasby, 1970, 1971	Mn nodds and assoc pelagic sedds; geochem of; Indian Ocean
Glasby, 1972d	Deposition of Mn oxides; effect of pressure; marine environment
Glasby, 1972e	Mn nodds; geochem of; NW Indian Ocean
Glasby, 1972g	Fe oxide phase; nature of; marine Mn nodds
Glasby, Tooms, and Cann, 1971	Mn encrustations; geochem of; Gulf of Aden
Glemser, 1939	New modification of MnO <sub>2</sub>
Goldberg, 1954	Chem scavengers of sea
Goldberg and Arrhenius, 1958	Pacific pelagic sedds; chem of

Goodell, 1968b	Fe-Mn concretions; elemental distrib; Southern Ocean
Grasselly, 1972	Mn <sub>3</sub> O <sub>4</sub> ; thermal stability and oxidation
Grasselly and Hetenyi, 1968	Adsorption properties of some Mn oxides
Grutter and Buser, 1957	Manganiferous seds
Hahn and Muan, 1960	System Mn-O: Mn <sub>2</sub> O <sub>3</sub> -Mn <sub>3</sub> O <sub>4</sub> and Mn <sub>3</sub> O <sub>4</sub> - MnO equilibria
Harrison and Peterson, 1965	Magnetic mineral; Indian Ocean
Hartmann, <u>et al.</u> , 1973	Pacific seds; geochem and soil- mechanical investigations
Hazel, 1940	Silicic acid as a protective colloid for MnO <sub>2</sub> sols
Healy, <u>et al.</u> , 1966	Mn dioxides; surface properties; effect of crystal structure
Hey, 1962	Cobaltic hydroxide in nature
Huebner, 1969	System Mn-C-O; stability of rhodochrosite
Irvine and Williams, 1953	Transition metal complexes; stability of
Jenkins, 1970	Hydrous MnO <sub>2</sub> , colloid chem of; Mn removal
Jenkins, 1973	δ-MnO <sub>2</sub> ; coagulation and adhesion to silica surfaces; effect of selected cation concentrations
Jenne, 1968	Mn, Fe, Co, Ni, Cu and Zn in soils and water; role of hydrous Mn and Fe oxides
Klingsberg and Roy, 1957	Stability and interconvertibility of phases in system Mn-O-OH
Kozawa, 1959	MnO <sub>2</sub> ; Fe -exchange property
Kraus, <u>et al.</u> , 1958	Ion exchange properties of hydrous oxides
Krause, 1928	Ortho-ferric acid hydrate to meta- ferric oxide hydrate; transformation



Krauskopf, 1967	Introduction to geochem
Krupyanskii and Suzdalev, 1973	Magnetic properties of ultrafine Fe oxide particles
Kulp and Perfetti, 1950	Thermal study of Mn oxide minerals
Kulp and Trites, 1951	Natural hydrous ferric oxides; DTA
Kundig, <u>et al.</u> , 1966	Properties of supported small $\alpha$ -Fe <sub>2</sub> O <sub>3</sub> particles determined with Mössbauer effect
Kurbatov, J. D., <u>et al.</u> , 1945	Hydrous ferric oxide; Sr and Ba ions; adsorption and exchange
Langmuir, 1969a	Gibbs free energy of substances in system Fe-O <sub>2</sub> -H <sub>2</sub> O-CO <sub>2</sub> at 25°C
Langmuir and Whittemore, 1971	Precipitated ferric oxyhydroxides; stability of
Levason and McAuliffe, 1972	Mn; higher oxidation state chem
Loganathan and Burau, 1973	Sorption of heavy metal ions by a hydrous Mn oxide
MacKenzie and Meldau, 1959	Fe oxide gels; aging of sesquioxide gels
MacKenzie, <u>et al.</u> , 1971	Oxides of Fe, Al, Mn
Mah, 1960	Thermodynamic properties of Mn and its compounds
Maier, 1934	Thermodynamic properties of Mn and its metallurgically important compounds
Mason, 1943	System FeO-Fe <sub>2</sub> O <sub>3</sub> -Mn <sub>2</sub> O <sub>3</sub> ; mineralogical aspects
McKenzie, 1967	Sorption of cobalt by Mn minerals; soils
McKenzie, 1970	Reaction of cobalt with MnO <sub>2</sub> minerals
McKenzie, 1971	Mn oxides and hydroxides; synthesis of
McKenzie, 1972	Sorption of some heavy metals by lower oxides of Mn

McKenzie and Taylor, 1968	Co assoc/w Mn oxide minerals; soils
McMurdie, 1944	Dry cells and their raw materials; microscopic and diffraction studies
Meylan, 1968b	Mn nodds; mineralogy and geochem; Southern Ocean
Michard, 1969a	Mn oxidation; kinetics of; sea floor
Michard, 1969b	Deposition of traces of Mn by oxidation
Millar, 1928	Specific heats at low temperatures of manganous oxide, manganous-manganic oxide and MnO <sub>2</sub>
Moore, T. E., <u>et al.</u> , 1950	Solid oxides and hydroxides of Mn
Morgan, J. J. and Stumm, 1964a	MnO <sub>2</sub> ; colloid-chem properties
Morgan, J. J. and Stumm, 1964b	Fe and Mn; multivalent metal oxides; limnological transformations
Muan, 1959	System Mn oxide-SiO <sub>2</sub> ; phase equilibria in air
Muller, J., <u>et al.</u> , 1965	Mn dioxides; ion-exchange
Murray, D. J., <u>et al.</u> , 1968	Colloidal hydrous Mn oxide; adsorption of aqueous metal
Murray, J. W., 1970a,b	Hydrous Fe and Mn oxides; surface chem
Murray, J. W., 1973	Hydrous MnO <sub>2</sub> ; interactions with Co
Nichol, Horsnail and Webb, 1967	Mn oxides; precipitation of; geochem patterns in stream sed
Nichols and Walton, 1972	Autoxidation of Mn hydroxide
Ogden and Reynolds, 1964	MnO <sub>2</sub> ; separation of trace metals: Sb and Sn from Bi
Okada, Minakuchi, and Shima, 1972	Thermal studies of Fe-Mn phase of Mn nod
Okada, Okada, and Shima, 1973	Magnetic properties and Mössbauer effect on Mn nodds
Okamoto, 1968	Structure of δ-FeOOH

Okamoto, <u>et al.</u> , 1972	Characterization and phase transformation of amorphous ferric hydroxide
Ozima, 1967	Magnetic properties of Mn nodds assoc/w dredged submarine basalts
Pernet, <u>et al.</u> , 1973	Characterization and study of a new variety of high pressure FeOOH by Mössbauer effect
Ponnamperuma, Loy, and Tianco, 1969	Mn oxide systems; redox equilibria; flooded soils
Ponnamperuma, Tianco, and Loy, 1967	Fe hydroxide systems; redox equilibria; flooded soils
Price, 1967	Mn-Fe oxides (nodds); geochem; ocean
Reynolds, G. F. and Tyler, 1964	Separation of trace metals by MnO <sub>2</sub> : behavior of Pb
Ridge and Boell, 1966	Ferromagnetic Fe (III) oxide monohydroxide
Robertson and Rancitelli, 1973	Trace element additions to sea water resulting from contact with Fe-Mn nod particles
Sackur and Fritzmman, 1909	Solubility of Mn hydroxides and dissociation pressure of Mn dioxides
Schossberger, 1940a,b	Natural and synthetic MnO <sub>2</sub> ; x-ray examination
Schwertmann and Taylor, 1972a	Lepidocrocite to goethite; transformation of
Schwertmann and Taylor, 1972b	Lepidocrocite to goethite; transformation of; influence of silicate
Shomate, 1943	Heats for formation of manganomanganic oxide and MnO <sub>2</sub>
Simon, 1937	System MnO-H <sub>2</sub> O
Taylor, R. M. and McKenzie, 1966	Trace elements assoc/w Mn minerals; Australian soils
Taylor, R. M., <u>et al.</u> , 1964	Mn; mineralogy and chem; Australian soils

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|---------------------------------------|---|
| Towe and Bradley, 1967                | Mineralogy of colloidal "hydrous ferric oxides"   |
| van der Giessen, 1966                 | Structure of Fe(III) oxide-hydrate gels   |
| van der Giessen, <u>et al.</u> , 1968 | Study of constitution and freezing behavior of Fe oxide-hydrate gels by Mössbauer effect    |
| Varentsov, 1971                       | Fe-Mn nods and crusts; formation of; recent basins  |
| Varentsov and Pronina, 1972           | Sorption by natural Fe-Mn oxides from seawater in the presence of complex-forming compounds |
| von der Borch and Rex, 1970           | Amorphous Fe oxide precipitates; sed cores; DSDP Leg 5                                      |
| Wadsley, 1950b                        | Hydrous Mn oxide with exchange properties   |
| Wadsley and Walkley, 1951             | Structure and reactivity of oxides of Mn  |
| Weisz, 1963                           | Deep-sea Mn nods as oxidation catalysts   |
| Whittemore and Langmuir, 1973         | Stability of ferric oxyhydroxides in natural waters   |

S E C T I O N 1 6

GEOCHEMICAL PROCESSES AND ENVIRONMENTAL CONTROLS  
RELEVANT TO Mn-NODULE FORMATION

This section lists reports on inorganic geochemical processes and environmental controls relevant to marine and freshwater manganese nodule formation. Articles dealing with biogeochemical topics are listed in Section 19a.

GEOCHEMICAL PROCESSES AND ENVIRONMENTAL CONTROLS RELEVANT TO Mn-NODULE FORMATION

Allsman, 1956	Oxidation and enrichment of Mn deposits; Butte, Montana
Anderson, B. J., <u>et al.</u> , 1973	Sorption of silver by poorly crystallized Mn oxides
Anikouchine, 1967	Dissolved chem substances in marine seds
Back and Barnes, 1965	Electrochem potentials and Fe; ground water flow patterns
Barnes, I. and Clark, 1969	Chem properties of ground water; effect on wells
Barnes, S. S., 1967a	Mineralogy and chem of Fe-Mn nods
Barnes, S. S., 1967b	Formation of Fe-Mn nods; ocean
Barnes, S. S., 1967c	Minor elements; Fe-Mn nods
Bartlett and Greggs, 1970a	Carbonate lithification on ridges and seamounts; Mid-Atlantic Ridge, 45°N
Bartlett and Greggs, 1970b	Styolitic solution surfaces from carbonate cores; San Pablo Seamount and Mid-Atlantic Ridge
Bender, 1971	Upward diffusion of Mn in pelagic seds
Bender, 1972	Trace metal removal; ocean
Berner, 1971	Chem sedimentology
Blume, 1968	Mottling and nod formation; soils
Bonatti, 1965a	Palagonite, hyaloclastites and alteration of volcanic glass in ocean
Bonatti, 1971	Mn fluctuations in sed cores; Caribbean
Bonatti, Fisher, <u>et al.</u> , 1971	Mobility of transition elements, P, U, and Th in seds; ocean
Borchert, 1965	Formation of sed Fe ores; marine

- Borchert, 1970 Mn; ore-deposition and geochem
- Boström, 1967a pH-controlling redox reactions in natural waters
- Boström, 1967b Excess Mn in pelagic seds
- Boström, 1970a Deposition of Mn-rich seds; glacial periods
- Boström, 1970f Origin of Mn-rich layers; seds; Arctic
- Boström, Kraemer, and Gartner, 1973 Provenance and accum rates of opaline silica, Al, Ti, Fe, Mn, Cu, Ni, Co in Pacific pelagic seds
- Bricker, 1965 Stability relations in system Mn-O<sub>2</sub>-H<sub>2</sub>O
- Broecker, et al., 1966 Evolution of Mn nod
- Brujevicz, 1938 Oxidation-reduction potential and pH of seds; Barents and Kara Seas
- Bruyevich and Kulik, 1967 Causes of decreased alkali in interstitial solutions of deep sea seds
- Buckley and Cranston, 1973 Geochem interactions between water and particulate solids; models for mechanisms of metal dispersion and accum in marine environments
- Burns, R. G., 1965 Cobalt (III) in amorphous FeOOH·nH<sub>2</sub>O phase of Mn nods
- Burns, R. G. and Fyfe, 1967 Crystal-field theory and geochem of transition elements
- Burns, V. M. and Burns, 1974 Cobalt uptake by Fe-Mn nods, soils and Mn(IV) oxides
- Byrne and Kester, 1974 Solubility of hydrous ferric oxide in sea water
- Calvert and Price, 1972 Diffusion and reaction profiles of dissolved Mn in pore waters of marine seds
- Chakravarti and Dhar, 1927 Adsorption of electrolytes by Mn dioxide

Champness, 1971	Transformation: manganite → pyrolusite
Cheney and Vredenburg, 1968	Fe sulfides in diagenetic formation of Fe-poor Mn nodds
Collins and Buol, 1970a	Fe and Mn precipitation under specified Eh-pH conditions; soil
Collins and Buol, 1970b	Fe and/or Mn equilibria; effects of Eh-pH fluctuations
Correns, 1941	Geochem of Fe and Mn
Craig, 1974	Scavenging model for trace elements in the deep sea
Crerar and Barnes, 1974	Deposition of deep-sea Mn nodds
Curtis and Spears, 1968	Formation of sed Fe minerals
Dasch, 1968	Sr-isotope variations in size-fractionated, deep-sea sedds; relationship to marine diagenesis of clay minerals
Dean, <u>et al.</u> , 1973	Geochem and accretion rates; Mn nodds; freshwater
DeGroot, 1966	Mobility of trace elements in deltas
Dennen and Anderson, 1962	Chem changes in rock weathering
Dhar and Kishore, 1950	Oxidation of Mn(OH) <sub>2</sub> in presence of other metallic hydroxides
Duval and Kurbatov, 1952	Adsorption of Co and Ba ions by hydrous ferric oxide at equilibrium
Dyck, 1971	Adsorption and coprecipitation of Ag on hydrous oxides of Fe and Mn
Ellis, <u>et al.</u> , 1970	Diffusion of Cu, Mn, Zn; soil
Ericson and Wollin, 1973	Precipitation of Mn oxide in sedds; ocean
Eristavi, 1948	Adsorption of Ni and Co from aqueous solutions by Mn oxides and Mn ores



Fayward, 1971	Relation between oxidation potential and Fe in ground water; aquifer; Louisiana
Feitknecht, Brunner, and Oswald, 1962	Influence of moisture content on the oxidation of Mn hydroxide by molecular oxygen
Ferguson, 1970	Co-precipitation of Fe and trace metals from aqueous solutions
Fischer and Garrison, 1967	Carbonate lithification on sea floor
Fomina, 1962	Oxidative-reduction processes in sed; SW Pacific
Fomina, 1966	REE; formation of Fe-Mn concretions; ocean
Fuerstenau, <u>et al.</u> , 1967	Leaching of Mn nod; ocean
Futral and Ingols, 1953	Cu catalysis for Mn oxidation
Gabano, <u>et al.</u> , 1965	Surface properties of $\alpha$ -MnO <sub>2</sub>
Ganapathy, <u>et al.</u> , 1968	Adsorption of trace elements in sed; near shore; ocean
Garrels, 1960	Mineral equilibria at low temperature and pressure
Garrels and Christ, 1965	Solutions, minerals and equilibria
Geloso, 1927	Adsorption on colloidal MnO <sub>2</sub>
Ghosh and Dean, 1974	Factors contributing to precipitation of elements in Fe-Mn nod and assoc sed
Gieskes, <u>et al.</u> , 1974	Geochem evidence for extensive diagenesis in DSDP Hole 245
Glagoleva, 1971	Chem of Fe-Mn nod in sed; NW Pacific
Glasby, 1974b	Marine Mn nod; mechanisms of incorporation of Mn and assoc trace elements
Goldberg, 1954	Chem scavengers of sea

Goldberg, 1961a	Chem; ocean
Goldberg, 1963a	Chem; ocean
Goldberg and Arrhenius, 1958	Chem of Pacific pelagic seds
Gorham and Swaine, 1965	Distrib of elements; influence of oxidizing and reducing conditions; lake seds
Govett and Pantazis, 1971	Distrib of Cu, Zn, Ni, Co; Troodos Pillow Lava Series, Cyprus
Grass, 1969	Tile clogging by Fe and Mn; Imperial Valley, Calif
Grasselly, 1972	Thermal stability and oxidation of $Mn_3O_4$
Grasselly and Hetenyi, 1968	Adsorption properties of some Mn oxides
Greenslate, Frazer, and Arrhenius, 1973	Origin and deposition of selected transition elements in seabed; Pacific
Hahn and Muan, 1960	System Mn-O: $Mn_2O_3$ - $Mn_3O_4$ -MnO equilibria
Hart, 1970	Chem exchange: sea water and basalts
Hartmann, 1964	Geochem of Fe and Mn in Baltic
Hartmann, <u>et al.</u> , 1973	Geochem and soil mechanical study; sed; Pacific
Hazel, 1940	Silicic acid as a protective colloid for $MnO_2$ sols
Healy, <u>et al.</u> , 1966	Mn dioxides; surface properties; effect of crystal structure
Hem, 1963	Chem equilibria and rates of Mn oxidation; relations between Mn in solution, Eh, pH, and sulfate, bicarbonate ion activities
Hem, 1964	Deposition and solution of Mn oxides; natural occurrence of Mn
Hem, 1972	Fe and Mn in aqueous solutions; chem factors

Hem and Cropper, 1959	Survey of ferrous-ferric chem equilibria and redox potentials
Hem and Skougstad, 1960	Coprecipitation effects in solutions containing ferrous, ferric and cupric ions
Hemstock and Low, 1953	Mn in colloidal fraction of soil
Henderson and Dale, 1970	Transition element ions: partitioning between olivine and ground mass; oceanic basalts
Hoover, 1966	Dissolution of Cu, Ni and Co from Mn nodds; ocean
Horn, M. K. and Adams, 1966	Computer-derived geochem balances and elemental abundances
Huber and Garrels, 1953	Relation of pH and oxidation potential to sed Fe mineral formation
Huebner, 1969	Rhodochrosite in system Mn-carbon-oxygen
Ignatieff, 1941	Ferrous iron in soils; behavior and determination
Irvine and Williams, 1953	Stability of transition-metal complexes
Jenkins, 1973	$\delta$ -MnO <sub>2</sub> ; coagulation and adhesion to silica surfaces; effect of selected cation concentrations
Jenne, 1968	Mn, Fe, Co, Ni, Cu and Zn in soils and water; role of hydrous Mn and Fe oxides
Jenne and Wahlberg, 1968	Radio-ion sorption; sed components role; stream
Klingsberg and Roy, 1960	Solid-solid and solid-vapor reactions; new phase in system Mn-O
Kovalev and Generalova, 1969	Geochem of movement of Fe; Recent peat bogs
Kovalyov and Lukashev, 1971	Geochem of Fe; peat bogs
Kozawa, 1959	Fe-exchange properties of Mn dioxide

Krause, 1928	Ortho-ferric acid hydrate to meta-ferric oxide hydrate; transformation
Krauskopf, 1957	Mn and Fe; sed processes
Krauskopf, 1967	Introduction to geochem
Krotov, 1950	Formation of Fe and Mn hydroxides; lakes
Kurbatov, J. D., <u>et al.</u> , 1945	Adsorption of Sr and Ba ions; exchange on hydrous ferric oxide
Kurbatov, M. H., <u>et al.</u> , 1951	Isothermal adsorption of Co from dilute solutions
Lahermo, 1971a	Chem denudation by ground water; Finnish Lapland
Landergren, 1948	Geochem of Fe ores and rocks; Sweden
Langmuir and Whittemore, 1971	Geochem of Fe in ground water; coastal New Jersey
Leeper, 1947	Mn in soil; forms and reactions
Lepp, 1963	Relation of Fe and Mn in sed Fe formations
Levason and McAuliffe, 1972	Higher oxidation state of Mn
Li, Bischoff, and Mathieu, 1969	Migration of Mn in sed; Arctic Basin
Listova, 1961	Physicochem conditions of formation of Mn oxide and carbonate ores
Ljunggren, 1953	Formation of Mn and Fe bog ores
Lynn and Bonatti, 1965	Mn in diagenesis of sed; ocean
MacKenzie and Meldau, 1959	Aging of sesquioxide gels: Fe oxide gels
Mah, 1960	Thermodynamic properties of Mn and its compounds
Makharadze, 1972	Sources and transfer of Mn, Si, Fe and P into sed; Georgia (USSR)
Mason, 1943	Mineralogical aspects of system FeO-Fe <sub>2</sub> O <sub>3</sub> -Mn <sub>2</sub> O <sub>3</sub>

McKenzie, 1967	Sorption of Co by Mn minerals; soils
McKenzie, 1971	Synthesis of Mn oxides and hydroxides
McKenzie, 1972	Sorption of some heavy metals by lower oxides of Mn
McMahon, 1969	Distrib of acid-soluble and total Fe; small lake
Michard, 1967a	Natural waters; significance of redox potential; Eh-pH diagrams
Michard, 1967b	Response to remarks re: Michard, 1967a
Michard, 1968	Co-precipitation of Mn ions and CaCO <sub>3</sub>
Michard, 1969a	Kinetics of Mn oxidation on sea floor
Michard, 1969b	Deposition of traces of Mn by oxidation
Moore, J. G., 1966	Palagonitization rate of submarine basalt; Hawaii
Morgan, J. J., 1967a	Chem thermodynamics in natural waters
Morgan, J. J. and Stumm, 1964b	Multivalent metal oxides in limnological transformations; Fe and Mn
Morgenstein, 1969	Palagonite in sed; Atlantic and Pacific
Morgenstein, 1972b	Sideromelane-palagonite transition in marine sed
Morgenstein, 1972c, 1973a	Sed diagenesis and rates of Mn accretion; Waho Shelf, Hawaii
Morgenstein and Felsher, 1971	Origin of Mn nod; palagonitization
Mortimer, 1941, 1942	Dissolved substance exchange: mud to water; lakes
Mortimer, 1971	Chem exchange: sed; to water; Great Lakes
Mottl, <u>et al.</u> , 1974	Chem exchange between sea water and MORB during hydrothermal alteration; experimental study

Muller, J., <u>et al.</u> , 1965	Ion-exchange of Mn dioxides
Murata, 1939	Exchangeable Mn in river and ocean muds
Murray, D. J., <u>et al.</u> , 1968	Adsorption of aqueous metal on colloidal hydrous oxide
Murray, J. W., 1969	Oxidation and reduction reactions in seawater
Murray, J. W., 1973	Interactions of Co with hydrous Mn dioxide
Nichol, <u>et al.</u> , 1967	Precipitation of Mn oxide; geochem patterns in stream sed
Nichols and Walton, 1942	Autoxidation of Mn hydroxide
Ogden and Reynolds, 1964	Separation of trace metals by Mn dioxide "collection"; Sb and Sn from Bi
Patrick and Turner, 1968	Effect of redox potential on Mn transformation; soil
Perrin, 1962	Hydrolysis of Mn(II) ion
Piper, 1973b	Fractionation of REE in seawater and marine sed
Pieruccini, 1951	Diffusion of Mn in limestone and chert sed; northern Toscana Appenines
Ponnamperuma, Loy, and Tianco, 1969	Redox equilibria; Mn oxide systems; soil
Ponnamperuma, Tianco, and Loy, 1967	Redox equilibria; Fe hydroxide systems; soil
Poon and DeLuise, 1967	Mn cycle in impoundment water
Presant, 1971	Geochem of Fe, Mn, Pb, Cu, Zn, As, Sb, Ag, Sn, Cd in soils; New Brunswick
Rex, 1967	Silicates formed by basaltic glass-sea water contact; Sylvania Guyot; Pacific

Reynolds, G. F. and Tyler, 1964	Separation of trace metals by Mn dioxide "collection"; Sb and Sn in Pb
Robertson and Rancitelli, 1973	Seawater contact with Fe-Mn nod particles; trace element additions
Robinson, 1930	Chem phases: submerged soil
Saunders, 1965	Phosphate retention; relation to free sesquioxides and organic matter; soil; New Zealand
Savage, 1936	Solution, transportation and precipitation of Mn
Schellman, 1971	Lateritic Fe, Ni, Al and Mn; relationship to source rock
Schwertmann and Taylor, 1972a	Transformation: lepidocrocite to goethite
Schwertmann and Taylor, 1972b	Transformation: lepidocrocite to goethite; influence of silicate
Seguin, 1972	Stability of MnCO <sub>3</sub> in inert atmospheres and air
Sevast'yanov, 1967	Formation of Fe-Mn concretions in sed; redistrib of arsenic; Black Sea
Sevast'yanov and Volkov, 1967	Chem elements in seds; Black Sea
Sherman and Kaneshiro, 1954	Fe concretions; origin and development; latosols; Hawaii
Sherman, <u>et al.</u> , 1949	Pyrolusite concretions; origin and composition; soil; Hawaii
Siegel, 1966	Zinc-glycine/ion exchange resins and clays; equilibrium binding
Sorem, 1973	Mn nodules as indicators of long-term variations in sea floor environment
Spencer and Brewer, 1971	Diffusion and redox potential controls; distrib of Mn and trace metals in water; Black Sea
Strakhov, 1965	Authigenous mineral parageneses in sed ores

Strakhov, 1966	Mn in present-day basins; Mn mineralization
Strakhov, 1968	Geochem processes in humid zones
Strakhov, 1969	Principles of lithogenesis
Strakhov and Nesterova, 1968	Influence of volcanism on geochem of marine deposits; Sea of Okhotsk
Tageeva and Tikhomirova, 1962	Geochem of pore solutions in diagenesis of marine seds
Theobald, <u>et al.</u> , 1963	Precipitation of Al, Fe and Mn; river; Colorado
Todd, 1903	Concretions: geological effects
Turekian, 1962	Rates of accum of several trace elements in a carbonate-rich Atlantic deep-sea core
Turekian and Kharkar, 1967	Trace metals: modes of supply and deposition; oceans
Tzur, 1971	Interstitial diffusion and advection of solute in seds
Varentsov, 1970a,b	Mn leaching; interaction of volcanic materials with sea water
Varentsov, 1971	Formation of Fe-Mn nodules and crusts; Recent basins
Varentsov, 1973	Geochem aspects of formation of Fe-Mn ores in shelf regions of Recent seas
Varentsov and Pronina, 1972	Sorption by Fe-Mn oxides from sea water
Varentsov and Pronina, 1973	Mechanisms of Fe-Mn ore formation in Recent basins; experimental data on Ni and Co
Varentsov and Stepanets, 1970	Leaching of Mn by sea water from mafic volcanic materials
Vogt, J. H. L., 1906	Mn-like metals: behavior toward Fe and Mn; ocean and trace-metal ores



Volkov and Sevastianov, 1968	Redistrib of chem elements; diagenesis of seds; Black Sea
Volkov, Rosanov, and Sokolov, 1971	Oxidation and reduction processes; seds; NW Pacific
Wangersky and Joensuu, 1967	Fractionation of carbonate cores; deep sea
Wilkniss, Carr and Hoover, 1970	Submarine volcanism and chem changes in sea water
Windom, 1971	Distrib and diagenesis of Fe, Mn, Ni, Co in Recent marine seds
Zsolnay, 1971	Diagenesis as function of redox conditions; organic and inorganic compounds; Baltic



## S E C T I O N 1 7

### FORMATION AND ORIGIN OF MANGANESE ACCUMULATIONS--GENERAL.

This section lists references dealing with the formation and origin of various types of manganese deposits, including oceanic and freshwater nodules, ferromanganiferous sediments, and ore deposits. Papers with titles proposing volcanic or biologic origins for nodules are found in sections 18a and 19a, respectively.

FORMATION AND ORIGIN OF MANGANESE ACCUMULATIONS--GENERAL

- |                                     |  |
|-------------------------------------|--|
| Andrews and Margolis, 1974          | Mn nods microstructure and genesis                                 |
| Andrews and Meylan, 1972            | Bottom photography; <u>Kana Keoki</u> cruise '72-Mn                |
| Andrushchenko and Skornyakova, 1966 | Formation of concretions   |
| Andrushchenko and Skornyakova, 1967 | Mn nods; composition, structure and features of formation; Pacific |
| Arrhenius, Mero and Korkisch, 1964  | Origin of Mn minerals; ocean                                       |
| Barnes, S. S., 1967b                | Formation of oceanic Fe-Mn nods                                    |
| Bender, <u>et al.</u> , 1966        | Evolution of Mn nods   |
| Bonatti and Nayudu, 1965            | Origin of Mn nods; ocean   |
| Bonatti, <u>et al.</u> , 1972       | Classification and genesis of submarine Fe-Mn deposits             |
| Broecker, <u>et al.</u> , 1966      | Evolution of Mn nod  |
| Burns, V. M. and Burns, 1973        | Mn nod authigenesis; mechanism for nucleation and growth           |
| Chaynikov, 1969                     | Source of Mn in sed; Pacific                                       |
| Cherdyntsev, <u>et al.</u> , 1971   | Origin of Mn nods; Pacific; radioisotope data                      |
| Crerar and Barnes, 1974             | Deposition of deep-sea Mn nods                                     |
| Elderfield, <u>et al.</u> , 1972    | Origin of Fe-Mn sed; Troodos Massif, Cyprus                        |
| Estep, 1973a,b                      | Formation of Fe-Mn deposits; infrared microanalysis                |
| Foster, 1970                        | Nature and origin of Mn nod internal features; ocean               |
| Foster, 1972                        | Growth history of Mn nods; Baja Calif Seamount Province            |

Goodier, 1972	Mn nod development
Grunwald, 1964	Mineralogy and origin of Mn concretions; South Dakota
Harriss and Troup, 1970	Chem and origin of Fe-Mn concretions; freshwater
Hollister, <u>et al.</u> , 1974	Current-controlled abyssal sedimentation; Samoan Passage
Immel, 1974	Origin of micromanganese nods determined from $U^{234}/U^{238}$ ratios
Kalienko, 1949	Origin of Fe-Mn concretions
Kennett and Watkins, 1975	Deep-sea erosion and Mn nod development; SE Indian Ocean
Kerl, 1970	Origin, properties, occurrence; Ni, Cu, and Co-rich ocean nods
Lalou, Brichet, and LeGressus, 1973	SEM and microanalysis study of Mn nod; implication for the mode of nod formation
Lalou, Brichet, and Ranque, 1973	Nods found at sed surface; possibility of formation contemporaneously with sedimentation
Manheim, 1972	Composition and origin of Mn-Fe nods and pavements; Blake Plateau
Mart and Sass, 1972	Geology and origin of Mn ore; Sinai
Morgenstein and Felsher, 1971	Origin of Mn nods; palagonitization
Ossa, 1970	Genesis of Mn deposits; N Chile
Payne and Conolly, 1972	Pleistocene Mn pavement production; relation to origin of Mn in Tasman Sea
Penn, 1968	Origin of Fe-Mn concretions in marine environment
Pettersson, 1959	Mn and Ni on ocean floor
Raab, 1972	Genesis; Pacific nods; physical and chem features

Rakhmanov and Chaykovskiy, 1972	Genetic types of sed Mn formations
Sapozhnikov, 1970	Genesis of Mn deposits; accum of Mn in seawater
Shterenberg, 1971	Formation of Fe-Mn nods; Gulf of Riga
Thiel, 1924	Mn minerals: their identification and paragenesis
Varentsov, 1971	Formation of Fe-Mn nods and crusts in Recent basins
Varentsov, 1972a	Formation of Fe-Mn nods and crusts in Recent basins; geochem studies; Eningi-Lampi Lake, central Karelia
Varentsov, 1972b	Main aspects of formation of Fe-Mn ores in Recent basins; Karelian lake
Varentsov, 1973	Geochem aspects of formation of Fe-Mn ores in shelf regions of Recent seas
Varentsov and Blazhtchishin, 1970	Formation of Fe-Mn nods and crust-like products on Baltic Sea floor
Varentsov and Pronina, 1973	Mechanisms of Fe-Mn ore formation in Recent basins; experimental data on Ni and Co

## S E C T I O N 1 8

### a - MARINE METALLOGENIC DEPOSITS AND FERROMANGANOAN SEDIMENTS

This section lists reports dealing with marine metallogenic deposits and ferromanganoan sediments, primarily those of the Mid-Atlantic Ridge and East Pacific Rise.

### b - ASSOCIATION OF Mn-NODULES WITH SUBMARINE VOLCANICS; VOLCANIC ORIGIN OF Mn-NODULES AND NODULE METALS

This section lists reports concerned with submarine volcanic rocks associated with ferromanganese deposits, as well as other lines of evidence for the volcanic origin of manganese nodules and their constituent metals.

MARINE METALLOGENIC DEPOSITS AND FERROMANGANOAN SEDIMENTS

- |  |  |
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| Aumento, 1969  | Fission track and Fe-Mn chronology;<br>Mid-Atlantic Ridge, 45°N                          |
| Aumento and Loncarevic, 1969                               | Mid-Atlantic Ridge, 45°N; Bald<br>Mountain   |
| Aumento, Loncarevic and Ross,<br>1971                      | Geology of Mid-Atlantic Ridge, 45°N;<br>Hudson geotraverse                               |
| Baturin, <u>et al.</u> , 1969                              | Composition and origin of Fe-ore sed<br>and hot brines; Red Sea                          |
| Bender, Broecker, Gornitz, and<br>Middel, 1970             | Accum rates of Mn and elements in sed;<br>East Pacific Rise                              |
| Bender, Broecker, Gornitz,<br>Middel, <u>et al.</u> , 1971 | Geochem of cores; East Pacific Rise  |
| Blissenbach, 1972  | Continental drift and metalliferous<br>sed   |
| Bonatti and Joensuu, 1966, 1967                            | Deep-sea Fe deposit; South Pacific   |
| Bonatti, Kraemer, and Rydell,<br>1972                      | Classification and genesis of Fe-Mn<br>deposits; ocean                                   |
| Boström, 1970b   | Geochem evidence for ocean floor<br>spreading; South Atlantic                            |
| Boström, 1970d   | Submarine volcanism as source for Fe   |
| Boström, 1970e   | Origin of Fe-rich sed; East Pacific<br>Rise  |
| Boström and Peterson, 1966                                 | Precipitates from hydrothermal<br>exhalations; East Pacific Rise                         |
| Boström and Peterson, 1967                                 | Hydrothermal exhalations and possible<br>ore-forming processes; East Pacific<br>Rise     |
| Boström, Peterson, <u>et al.</u> , 1968                    | Origin of anomalous seds in areas of<br>high-heat flow; East Pacific and<br>Indian Ocean |



- Boström, Peterson, et al., 1969      Ferromanganoan seds on active volcanic ridges
- Butuzova, 1966      Composition and origin of Fe ore seds; Santorini Volcano
- Butuzova, 1968      Effect of volcanism in formation of Recent seds; Santorini Caldera
- Cook, 1971      Fe and Mn rich seds over basalt; Equat Pacific
- Corliss, 1970      MORB: origin of submarine hydrothermal solutions; regional diversity along Mid-Atlantic Ridge
- Corliss, 1971      Origin of metal-bearing submarine hydrothermal solutions
- Corliss, et al., 1972      REE data for Fe- and Mn-rich seds assoc/w sulfide ore bodies of Troodos Massif, Cyprus
- Cronan, 1972c      Al, As, Hg, and Mn in ferruginous seds; median valley, Mid-Atlantic Ridge, 45°N
- Cronan and Garrett, 1973a      Partition of elements in basal sed; East Pacific
- Cronan and Garrett, 1973b      Distribution of elements in metalliferous Pacific seds collected during DSDP
- Cronan, et al., 1972      Fe-rich basal sed; East Equat Pacific; DSDP Leg 16
- Dasch, Dymond and Heath, 1971      Isotopic analysis of metalliferous sed; East Pacific Rise
- Dasch, Heath and Dymond, 1971      Isotopic analysis of metalliferous sed; East Pacific Rise
- Dymond, Corliss, et al., 1972      DSDP and East Pacific Rise seds; chem, isotopic and mineralogical study
- Dymond, Corliss, et al., 1973      Origin of Pacific metalliferous seds
- Dymond, Heath, et al., 1973      Elemental and isotopic geochem of metalliferous seds; East Pacific Rise

- Govett and Pantazis, 1971      Distrib of Cu, Zn, Ni, Co in Troodos  
Pillow Lava Series, Cyprus
- Manheim, Hathaway, et al., 1966      Geochem of Recent Fe deposits in Red  
Sea
- Melson, et al., 1968      Volcanism and metamorphism; Mid-  
Atlantic Ridge, 22°N
- Miller, et al., 1966      Hot brines and Recent Fe deposits;  
Red Sea
- Piper, 1973c      Origin of metalliferous seds; East  
Pacific Rise
- Puchel, et al., 1973      Recent marine Fe-ores off Thera,  
Greece; geochem, genesis, mineralogy;  
bacterial genesis of Fe hydroxide seds
- Robertson and Hudson, 1973      Cyprus umbers: chemical precipitates  
on a Tethyan ocean ridge
- Rydell and Bonatti, 1973      Uranium in submarine metalliferous  
deposits
- Rydell, et al., 1974      Postdepositional injections of uranium-  
rich solutions into East Pacific Rise  
seds
- Sayles and Bischoff, 1973      Equat East Pacific; Fe-Mn seds
- Schwarz, 1968      Thermomagnetic properties of banded  
Mn sed; Mid-Atlantic Ridge
- Scott, M. R., Scott, Nalwalk,  
et al., 1973      Hydrothermal Mn in median valley,  
Mid-Atlantic Ridge
- Scott, M. R., Scott, Rona,  
et al., 1974      Rapidly accum Mn deposit; median  
valley, Mid-Atlantic Ridge
- Scott, R. B., Scott, et al.,  
1974      TAG hydrothermal field
- Scott, R. B., Rona, et al., 1972      Mn crusts; Atlantis Fracture Zone
- Seibold, 1973      Recent submarine metallogeny
- Shatskiy, 1964      Volcanologic-sedimentary Mn formations
- Zelenov, 1963      Underwater volcanism: role in  
formation of seds

ASSOCIATION OF Mn-NODULES WITH SUBMARINE VOLCANICS; VOLCANIC ORIGIN OF  
Mn-NODULES AND NODULE METALS

Arrhenius and Bonatti, 1965	Neptunism and volcanism; ocean
Aumento and Loncarevic, 1969	Mid-Atlantic Ridge, 45°N; Bald Mountain
Aumento, Loncarevic, and Ross, 1971	Geology of Mid-Atlantic Ridge, 45°N; Hudson geotraverse
Bertine, 1974	Origin of Lau Basin Rise sed
Bonatti, 1965a	Palagonite, hyaloclastites and volcanic glass; ocean
Bonatti, 1966	Volcanogenous minerals in pelagic seds; Pacific
Bonatti, 1967	Deep-sea volcanism; South Pacific
Bonatti, 1970	Deep-sea volcanism
Bonatti and Nayudu, 1965	Origin of Mn nods; ocean
Bonatti, Kraemer, and Rydell, 1972	Classification and genesis of Fe-Mn deposits; ocean
Boström, 1970d	Submarine volcanism as source for Fe
Boström and Fisher, 1971	Volcanogenic U, V, Fe in Indian Ocean seds
Boström and Peterson, 1967	Hydrothermal exhalations and possible ore-forming processes; East Pacific Rise
Boström, Joensuu, Valdes, and Riera, 1972	Geochem history of sed; South Atlantic
Cann, 1970	Petrol of basalts; dredged; Gulf of Aden
Cann and Vine, 1966	Petrol and magnetics; Carlsberg Ridge
Dasch, Dymond, and Heath, 1971	Isotopic analysis of metalliferous sed; East Pacific Rise

- Dasch, Heath, and Dymond, 1971 Isotopic analysis of metalliferous sed; East Pacific Rise
- Elderfield, 1972a Effects of volcanism on water chem; Deception Island, Antarctica
- Elderfield, et al., 1972 Origin of Fe-Mn sed; Troodos Massif, Cyprus
- Fein, et al., 1974 Geochem of seawater assoc/w actively forming pillow lava; Puna-Kau, Hawaii
- Ferguson and Lambert, 1972 Volcanic exhalations and metal enrichments; Matupi Harbor, New Britain
- Glasby, 1973c Role of submarine volcanism in controlling the genesis of Mn nod
- Hamilton and Rex, 1959 Lower Eocene phosphatized Globigerina ooze; Sylvania Guyot, Pacific
- Hart, R. A., 1973 Model for chem exchange in basalt-seawater system of oceanic layer II
- Horn, M. K. and Adams, 1966 Geochem balances and elemental abundances; computer derived
- Jenkyns, 1970b Submarine volcanism of Toarcian Fe pistolites; Sicily
- Lindstrom, 1974 Volcanic contribution to Ordovician pelagic sed
- Mathews, D. H., 1961 Lavas from abyssal hill; North Atlantic
- Mathews, D. H., 1962 Altered lavas, NE Atlantic
- Mathews, D. H., 1971 Altered basalts from abyssal hill and seamount; NE Atlantic
- Mathews, et al., 1965 Geology; Carlsberg Ridge
- Menard, 1960 Consolidated slabs on floor of East Pacific
- Moore, J. G. and Fiske, 1969 Volcanic substructure; dredge and photos; ocean; Hawaii

Morgenstein, 1967	Authigenic cementation of sed; Society Ridge, South Pacific
Morgenstein, 1969	Composition and development of palagonite in sed; Atlantic and Pacific
Morgenstein, 1972a	Mn accretion at sed-water interface; Hawaiian Archipelago
Morgenstein, 1972b	Sideromelane-palagonite transition; authigenic marine seds
Morgenstein, 1972c, 1973a	Sed diagenesis and rates of Mn accretion; Waho Shelf, Hawaii
Morgenstein and Felsher, 1971	Origin of Mn nodules; palagonitization
Mottl, <u>et al.</u> , 1974	Chem exchange between sea water and MORB during hydrothermal alteration; experimental study
Murdmaa, <u>et al.</u> , 1972	Volcanogenic clastic rocks; Pacific
Nayudu, 1964	Palagonite tuffs (hyaloclastites)
Nayudu, 1965a	Petrology of volcanics and sed; Mendocino Fracture Zone
Nayudu, 1965b	Petrology and chem of palagonite and Mn encrustations; Atlantic and Pacific
Ozima, 1967	Magnetic properties of Mn nodules assoc/w dredged submarine basalts
Paakkola, 1971	Volcanic complex and manganiferous Fe formation; Finnish Lapland
Park, 1946	Spilite and Mn problems; Olympic Peninsula, Washington
Paster, 1968, 1971	Petrologic variations within submarine basalt pillows; South Pacific-Antarctic
Peterson and Griffin, 1964	Volcanism and clay minerals; SE Pacific
Pettersson, 1959	Mn and Ni on ocean floor

Rex, 1967	Authigenic silicates formed from basaltic glass by contact with sea water; Sylvania Guyot, Marshall Islands
Skornyakova and Petelin, 1967	Seds; central South Pacific
Strakhov, 1964a	Importance of volcanic activity in formation of sed rocks
Strakhov, 1964b	Lithogenesis of volcanic sed type
Strakhov and Nesterova, 1968	Influence of volcanism on geochem of marine deposits; Sea of Okhotsk
Taliafero and Hudson, 1943	Mn deposits of Coast Ranges of Calif; genesis
Taylor, P. S. and Stoiber, 1971	Soluble material on ash from Central American volcanoes
Varentsov, 1970a,b	Mn leaching during interaction of basic volcanic materials with sea water
Varentsov and Stepanets, 1970	Leaching of Mn by sea water from mafic volcanic materials
White and Waring, 1963	Volcanic emanations
Wilkniss, Carr, and Hoover, 1970	Submarine volcanism and chem changes in sea water
Wilkniss, Warner, and Carr, 1971	Geochem of F, Fe, and Mn in coastal waters and freshwater springs; Hawaii
Wiseman, 1937	Geology and mineralogy of basalts; Carlsberg Ridge
Zelenov, 1963	Underwater volcanism: role in formation of seds
Zelenov, 1964	Fe and Mn in exhalations of submarine volcano; Indonesia
Zies, 1929	Acid gases contributed to sea during volcanic activity; Valley of Ten Thousand Smokes, Alaska
Zotov, 1968	Present-day formation of certain Mn minerals; Mendeleev Volcano on Kunashir Island

## S E C T I O N 1 9

### a - BIOGEOCHEMISTRY OF MANGANESE AND RELATED ELEMENTS

This section lists reports on the biogeochemistry of manganese and related or associated elements, particularly iron.

### b - BIOLOGICAL ORIGIN OF NODULES; ASSOCIATION OF ORGANISMS AND Mn-NODULES

This section lists reports on the association of micro-organisms and marine invertebrates with manganese nodules, as well as other lines of evidence for the biological origin of ferromanganese deposits.

## BIOGEOCHEMISTRY OF MANGANESE AND RELATED ELEMENTS

- |                              |   |
|------------------------------|---|
| Ahrens, 1966                 | Ionization and metal amino acid; sed cycle  |
| Alexandrov, 1962             | Sed cycle of Mn and its practical implication                                     |
| Allen, 1960                  | Mn on shells of living molluscs   |
| Aristovskaya, 1965           | Microbiology of podzolic soils  |
| Aschan, 1932                 | Peat bogs; participation in ore formation in northern fresh waters                |
| Baas Becking and Moore, 1959 | Relation between Fe and organic matter in seds                                    |
| Baier, 1937                  | Significance of bacteria for formation of oxygenic Fe and Mn                      |
| Baker, 1973                  | Mineral degradation and metal mobilization in soils; role of humic acid; Tasmania |
| Belov, <u>et al.</u> , 1966  | Distrib of Fe, Mn carbonates and organic material in seds; Arctic Ocean           |
| Bender, 1972                 | Trace metal removal; ocean  |
| Boucher, 1972                | Mn porphyrin complexes  |
| Bowen, 1956                  | Sr and Ba in sea water and marine organisms                                       |
| Bradley, 1910                | Mn in tissues of lower animals  |
| Bromfield and Skerman, 1950  | Biological oxidation of Mn; soils   |
| Chaffee, 1970                | Mn in geological and botanical materials; atomic absorption                       |
| Chipman and Schommers, 1968  | Uptake of radioactive Mn by clam  |
| Chipman and Thommeret, 1970  | Mn and fallout $^{54}\text{Mn}$ in marine benthos; Mediterranean                  |
| Crerar, <u>et al.</u> , 1972 | Sed geochem of Mn; organic controls   |



- Cross, Duke, and Willis, 1970      Biogeochem of trace elements; distrib of Mn, Fe and Zn in seds, water, and polychaetous worms; coastal plain estuary
- Dorff, 1935      Biological cycling of Fe and Mn
- Ehrlich, H. L., 1971b      Fate of Fe, Cu, Ni, Co in the bacterial reduction of manganic oxide in Fe-Mn nodules
- Ehrlich, H. L., 1973b      Mn cycle in sea
- Ehrlich, H. L., Ghiorse, and Johnson, 1972      Distrib of microbes in Mn nodules; Atlantic and Pacific
- Fujita, et al., 1969      Ash, Fe, Mn in marine plankton
- Gabe, et al., 1965      Formation of Mn-Fe layers in mud as a biogenic process
- Goldberg, 1952      Fe assimilation by marine diatoms
- Goldberg, 1957      Biogeochem of trace metals
- Gordon, C. M., et al., 1970      Na and Mn content of barnacle shells; influence of environment
- Gorshkova, 1958      Organic matter and carbonates in seds; Barents Sea
- Hariya and Kikuchi, 1964      Precipitation of Mn by bacteria in mineral springs
- Harriss and Pilkey, 1966      Skeletal Na, Mn, and Fe in Dendraster excentricus; temperature and salinity controls
- Heukelekian and Dondero, 1964      Aquatic microbiology
- Hochester and Quastel, 1952      Mn dioxide: respiratory system
- Horvath, 1972      Availability of Mn and Fe to plants and animals
- Ingols and Enginun, 1968      Biological studies of Mn solution
- Johnson, A. H. and Stokes, 1966      Mn oxidation by Sphaerotilus discophorus
- Jones, R., 1972      Effect of Mn on growth of dune slack plants

Kossaya, 1967	Composition of Mn oxides in <u>Metallogenium</u> cultures
Kovalev and Generalova, 1969	Fe in recent peat bogs; geochem; Byelorussia, USSR
Kovalyov and Lukashev, 1971	Geochem of Fe in peat bog process
Krinsley, 1959	Mn in gastropod shells
Krumbein, 1971	Mn-oxidizing fungi and bacteria
Kuznetsov, <u>et al.</u> , 1963	Geological microbiology
Laevastu and Thompson, 1956	Determination and occurrence of Ni in sea-water, marine organisms and sed
Leeper and Swaby, 1940	Oxidation of manganous compounds by microorganisms in soil
Lighthart, 1963	Sulfate-reducing bacteria; reservoir, S Calif
Livingston and Thompson, 1971	Trace elements in corals
Ljunggren, 1951	Biogeochem of Mn
Mai-thi and Ponnampereuma, 1966	Effect of Ca carbonate, Mn dioxide, ferric hydroxide and flooding on chem changes and rice growth; soil
Mann and Quastel, 1946	Mn metabolism in soils
Martin and Knauer, 1973	Elemental composition of plankton
Merlini, <u>et al.</u> , 1965	Mn in molluscs; activation analysis; lake
Mirchink, <u>et al.</u> , 1970	Satellite fungi of Mn-oxidizing bacteria
Moese and Brautner, 1966	Microbiological studies of Mn-oxidizing bacteria
Mullin and Riley, 1956	Cd in seawater, marine organisms and sed
Oborn, 1964	Mn and elements in aquatic organisms
Parker, R. B. and Toots, 1970	Minor elements in fossil bone

- Perkins and Norvielli, 1962 Bacterial leaching of Mn ores
- Preston, et al., 1972 Heavy metals in seawater, suspended matter and biological indicators; British Isles
- Robertson, et al., 1968 Elements in seawater, marine organisms and sed; neutron activation analysis
- Schulz-Baldes and Lewin, 1975 Chlamydomonus zygospores; Mn encrustation
- Schurin, 1965 Effect of Mn on distrib of bottom invertebrates; Baltic
- Schweisfurth and Mertes, 1962 Mn sludge deposition in pressure pipe for reservoir; microbiological and chem investigations on formation and control
- Serdobol'skii and Sinyagina, 1953 Base-acid conditions for formation of soluble organic compounds of Mn
- Shimoda, et al., 1964 Fluorine and Mn in fossil bones
- Siegel, 1966 Fe and Mn attract metal chelates; clay mineral studies
- Thomas, M. L. H., 1965 Mn on shells of snails; river; Prince Edward Island, Canada
- Tyler, 1970 Hyphomicrobia and oxidation of Mn; aquatic
- Tyler and Marshall, 1967a Hyphomicrobia: a factor in Mn problems
- Tyler and Marshall, 1967b Mn-oxidizing bacteria; form and function
- Tyler and Marshall, 1967c Microbial oxidation of Mn in hydro-electric pipelines
- Wangersky, 1963 Mn in ecology
- Wangersky and Joensuu, 1964 Sr, Mg, Mn in fossil foram carbonates
- Wangersky and Joensuu, 1967 Fractionation of carbonate cores; ocean
- Wiedman and Fetner, 1957 Anaerobic reduction of Mn; reservoirs

Wolfe, R. S., 1964

Fe and Mn bacteria

Wood, 1967

Microbiology of oceans and estuaries

Zapffe, 1931

Deposition of Mn; bacteria as catalyst

Zavarzin, 1964

Mn deposition on mollusk shells

Zsolnay, 1971

Diagenesis; organic and inorganic  
compounds; Baltic

BIOLOGICAL ORIGIN OF NODULES; ASSOCIATION OF ORGANISMS AND Mn-NODULES

- Beals and Trost, 1965                      Biochem of Mn concretions
- Buckley, et al., 1974                      Fe and Mn encrusted organic tubes; NE Mediterranean; Recent sed
- Butkevich, 1928a,b                      Micro-organisms; formation of marine Fe and Mn deposits
- Clute and Grant, 1974                      Organic matter and Fe-Mn concretions; Chautauqua Lake, NY
- De Castro and Ehrlich, 1970                      Reduction of Fe oxide minerals by marine bacillus
- Demel and Mankowski, 1951                      Quantitative studies of benthic fauna; southern Baltic
- Demel and Mulicki, 1954                      Quantitative studies of biological efficiency; floor of southern Baltic
- Dudley and Margolis, 1974                      Fe and trace element concentrations in marine Mn nods by benthic agglutinated forams
- Ehrlich, H. L., 1963a                      Bacterial action on Mn in nod enrichments
- Ehrlich, H. L., 1963b                      Bacteriology of Mn nods
- Ehrlich, H. L., 1964                      Microbial transformations of minerals
- Ehrlich, H. L., 1966                      Bacteria from marine Fe-Mn nods; reactions with Mn
- Ehrlich, H. L., 1968                      Mn oxidation by cell-free extract from Mn nod bacterium
- Ehrlich, H. L., 1970a,b                      Microbiology of Mn nods
- Ehrlich, H. L., 1971a                      Bacteriology of Mn nods; effect of hydrostatic pressure on bacterial oxidation of Mn<sup>+2</sup> and reduction of MnO<sub>2</sub>
- Ehrlich, H. L., 1971b                      Bacterial reduction of manganic oxide in Fe-Mn nods; fate of Fe, Cu, Ni, Co

- Ehrlich, H. L., 1972  
Microbes; Mn nod genesis and degradation
- Ehrlich, H. L., 1973a  
Biology of Fe-Mn nods; effect of freezing on nodule flora; identification of MnO<sub>2</sub>-reducing cultures
- Ehrlich, Ghiorse, and Johnson, 1972  
Distrib of microbes in Mn nods; Atlantic and Pacific
- Ehrlich, Yang, and Mainwaring, 1971  
Bacterial reduction of manganic oxide in Fe-Mn nods; fate of Fe, Cu, Ni, and Co
- Gabe, Troshanov, and Sherman, 1965  
Formation of Mn-Fe layers in mud as a biogenic process
- Glasby, 1973a  
Distrib of Mn nods and lebenspuren; underwater photos; Carlsberg Ridge
- Glasby and Hodgson, 1971  
Distrib of organic pigments in Mn nods; NW Indian Ocean
- Graham, 1959  
Metabolically induced precipitation of trace elements from seawater
- Graham and Cooper, 1959  
Biological origin of Mn; seafloor deposits
- Greenslate, 1974a  
Microorganisms participate in the construction of Mn nods
- Greenslate, 1974b  
Mn and biotic debris assoc in some deep-sea seds
- Greenslate, Frazer, and Arrhenius, 1973  
Origin and deposition of selected transition elements in seabed
- Greenslate, Hessler, and Thiel, 1974  
Mn nods are alive and well on sea floor
- Gurevich, 1964  
Role of micro-organisms in formation of Fe-Mn ores; lakes
- Harder, 1919  
Fe-depositing bacteria: geologic relations
- Hartmann, et al., 1973  
Geochem and soil mechanical study; seds; Pacific

Kalienko, 1949	Origin of Fe-Mn concretions
Kalienko, <u>et al.</u> , 1962	Bacteriogenic Fe-Mn concretions; Indian Ocean
Krumbein, 1971	Mn oxidizing fungi and bacteria
Ljunggren, 1953	Formation of manganiferous and ferriferous bog ores
Ljunggren, 1955a	Chem and radioactivity of Mn and Fe bog ores
Ljunggren, 1955b	Fe and Mn in bog ores; DTA and x-ray examination
Mirchink, <u>et al.</u> , 1970	Satellite fungi of Mn-oxidizing bacteria
Molisch, 1892	Plants and their relation to Fe
Molisch, 1920	Fe bacteria
Monty, 1973	Mn nodds are oceanic stromatoliths
Perfil'ev, <u>et al.</u> , 1965	Role of microorganisms in formation of Fe-Mn deposits; capillary microscopy
Peterson and Robertson, 1973	Adsorption of organic compounds from seawater to sed and Mn nod particles
Pronina, <u>et al.</u> , 1974	Uptake of biogenic forms of Ni and Co from sea water by natural hydroxides of Fe and Mn
Puchel, <u>et al.</u> , 1973	Recent marine Fe-ores off Thera, Greece: geochem, genesis, mineralogy; bacterial genesis of Fe hydroxide seds
Schoettle and Friedman, 1973	Organic carbon in seds; Lake George, NY
Schulz-Baldes and Lewin, 1975	<u>Chlamydomonas</u> zygospores; Mn encrustation
Shterenberg, 1967	Biogenic structures in Mn ores
Silverman and Ehrlich, 1964	Microbial formation and degradation of minerals

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| Sokolova-Dubinina and Deryugina,<br>1967 | Study of formation of Fe-Mn nods in<br>Lake Punnus-Yarvi               |
| Sorokin, 1972                            | Biological role in sedimentation of<br>Fe, Mn, Co in formation of nods |
| Stetson, Squires, and Pratt, 1962        | Coral banks occurring in deep water<br>on Blake Plateau                |
| Thiel, 1925                              | Mn precipitated by microorganisms                                      |
| Thomas and Blumer, 1964                  | Pyrene and fluoranthene in Mn nods                                     |
| Trimble and Ehrlich, 1968                | Reduction of MnO <sub>2</sub> by nodule bacteria                       |
| Trimble and Ehrlich, 1970                | MnO <sub>2</sub> - reductase system in marine<br>bacillus              |
| Wendt, 1974                              | Encrusting organisms in deep-sea Mn<br>nods                            |



## S E C T I O N 2 0

### INTERNAL STRUCTURE AND EXTERNAL MORPHOLOGY OF NODULES

This section lists articles containing information on the internal physical structure and external morphology of manganese nodules and other ferromanganese accumulations.

## INTERNAL STRUCTURE AND EXTERNAL MORPHOLOGY OF NODULES

Andrews and Margolis, 1974	Mn nods microstructure and genesis
Andrews, Callender, <u>et al.</u> , 1974	Fe-Mn deposits on ocean floor; NE Equat Pacific; <u>Moana Wave</u> cruise Mn 74-01
Andrushchenko and Skornyakova, 1967	Mn nods; composition, structure and features of formation; Pacific Ocean
Andrushchenko and Skornyakova, 1969	Texture and mineral composition of Fe-Mn concretions; South Pacific
Aumento, Lawrence, and Plant, 1968	Fe-Mn pavement; San Pablo Seamount
Beals and Trost, 1965	Biochem of Mn concretions
Brooke, 1968	Texture and hydrometallurgical processing of Mn nods
Dunham and Glasby, 1974	Petrographic and electron microprobe investigation; some deep- and shallow-water Mn nods
Fewkes, 1973	External and internal features of marine Mn nods; SEM; implications in nod origin
Fewkes, <u>et al.</u> , 1974	Cu-Ni rich segregations in Mn nods; Pacific
Foster, 1970	Internal nature and origin of marine Mn nods
Foster, 1972	Growth history of Mn nods; Baja Calif Seamount Province
Friedrich, Kunzendorf, and Plüger, 1974	Geochem of Mn nods; EDX-technique; Pacific; <u>Valdivia</u>
Friedrich, Rosner, and Demirsoy, 1969	Mn concretions; ore-microscopy and micro-analytic studies; Pacific
Ganung and Lasko, 1966	Structure and composition of Mn nods
Glasby, 1972a	Mn deposits; SW Pacific

Glasby, Meylan, and Backer, 1974	Distrib and morphology of Mn nodds; SW Pacific Basin
Goodell, <u>et al.</u> , 1971	Fe-Mn deposits; South Pacific, Drake Passage, Scotia Sea
Grant, 1967	Chem and mineralogy, distrib and physical aspects of Mn concretions; Southern Oceans
Grant, 1968	Morphology and composition of Fe-Mn concretions; environmental controls; Southern Ocean
Halbach, 1974	Comparison of properties of limnic and marine Fe-Mn nodds
Harriss and Troup, 1969	Chem and internal structure of Fe-Mn concretions; freshwater
Hubred, 1970b,c	Morphology and metal content of Mn nodds; abyssal hill
Margolis and Glasby, 1972	Micro-laminations in Mn nodds; SEM; central Pacific
Margolis and Glasby, 1973	Micro-laminations in Mn nodds; SEM; marine
McFarlin, 1967	Aragonite in Mn nodds; marine
Meyer, 1973a,b	Surface sed and Mn nod facies; <u>Valdivia</u> cruises 1972/73; NE Equat Pacific
Meylan, 1968b	Mn nodds; mineralogy and geochem; Southern Ocean
Morgenstein, 1970, 1971	Growth morphology of deep-sea Mn meganodules
Murray and Renard, 1891	Mn nodds; HMS <u>Challenger</u> voyage
Naumann, 1930	European inland waters; shapes of freshwater ore nodds
Raab, 1972	Physical and chem features of Mn nodds; implications to genesis of nodds; Pacific

Skornyakova and Andrushchenko, 1971	Morphology and internal structure of Fe-Mn nods; Pacific
Sorem, 1967	Internal structure of Mn nods
Sorem, 1973	Mn nods as indicators of long-term variations in sea floor environment
Sorem and Foster, 1969	Growth history of Mn nods; west of Baja Calif
Sorem and Foster, 1972a	Internal structure of Mn nods; implications in beneficiation
Sorem and Foster, 1972c	Marine Mn nods; importance of structural analysis
Sorem and Foster, 1973	Mineralogy, chem, and optical study; growth and economic potential of Mn nods; ocean
Strakhov, 1966	Types of Mn accums in present-day basins; significance in understanding Mn mineralization
Todd, 1903	Morphology of nods and crystals; land and ground water
Wiseman, 1937	Geology and mineralogy of basalts; Carlsberg Ridge
Woo, 1973	Marine Mn micro- and pebble-sized nods and freshwater Mn nods; scanning electron micrographs
Wyn Hughes, 1971	Zoned nodules; Malaita Island, Solomon Islands

## S E C T I O N 2 1

### RADIOGEOCHEMISTRY OF NODULES AND ASSOCIATED SEDIMENTS; RATES OF NODULE GROWTH

This section lists reports dealing with radio-isotopes in manganese nodules, associated sediments, and seawater, and radiochemical determination of nodule ages and growth rates. Reports on non-radiochemical determinations of manganese accumulation rates are also included.

RADIOGEOCHEMISTRY OF NODULES AND ASSOCIATED SEDIMENTS; RATES OF NODULE GROWTH

Amin, <u>et al.</u> , 1966	Cosmogenic Be <sup>10</sup> and Al <sup>26</sup> in marine seds
Arnold, 1958	Trace elements and transport rates; ocean
Arrhenius and Korkisch, 1959	U and Th in minerals; marine
Arrhenius, Bramlette, and Picciotto, 1957	Radioactive and stable heavy nuclides in seds; ocean
Aumento, 1969	Fission track and Fe-Mn chronology; Mid-Atlantic Ridge, 45°N
Baranov and Kuzmina, 1958	Radiochem analyses of deep-sea seds; determination of sed accum rate
Barnes, S. S. and Dymond, 1967	Accum rates of Fe-Mn nods
Bender, Ku, and Broecker, 1966	Mn nods: evolution
Bender, Ku, and Broecker, 1970	Accum rates of Mn in pelagic seds and nods
Bender, Broecker, Gornitz, and Middel, 1970	Accum rates of Mn and elements in seds; East Pacific Rise
Benes and Garba, 1966	Radiotracer study of Mn adsorption in glass from dilute aqueous solution
Bhandari, <u>et al.</u> , 1971	Determination of natural radio nuclides in marine deposits; rapid beta gamma coincidence technique
Bhat, Krishnaswami, <u>et al.</u> , 1969	Th <sup>234</sup> /U <sup>238</sup> ratios in ocean
Bhat, Krishnaswami, <u>et al.</u> , 1970	Radiometric and trace element studies of Fe-Mn nods
Bonatti, Fisher, <u>et al.</u> , 1971	Mobility of elements, P, U, and Th in seds; ocean
Broecker, <u>et al.</u> , 1966	Evolution of Mn nod
Buchowiecki and Cherry, 1968	Th, Ra, and K in Mn nods

Burton, 1965	Radioactive nuclides in sea water, marine seds and marine organisms
Cherdyntsev, <u>et al.</u> , 1971	Radioisotope data; origin of Mn nodds; Pacific
Chipman and Schommers, 1968	Organisms; uptake of radioactive Mn by clam
Chipman and Thommeret, 1970	Mn and fallout <sup>54</sup> Mn in marine benthos; Mediterranean
Chow and McKinney, 1958	Pb in Mn nodds; mass spectrometric determination
Chow and Patterson, 1959a	Pb isotopes in Mn nodds
Chow and Patterson, 1959b	Isotopic composition and Pb in pelagic sedds and Mn nodds
Chukhrov, <u>et al.</u> , 1966	Age determination for K-carrying Mn minerals
Dean, <u>et al.</u> , 1973	Geochem and accretion rates for Fe-Mn nodds; freshwater
Duffey, <u>et al.</u> , 1972	Neutron capture gamma ray studies of geological materials
Efimova and Nikolaev, 1965	Radiochem composition of Fe-Mn concretions and Mn ores
Fisher, D. E. and Boström, 1969	Uranium-rich sedds; East Pacific Rise
Flerov, 1970	Fe-Mn nodds; search for remote trans-uranium elements
Goel, <u>et al.</u> , 1957	Be <sup>10</sup> concentration in deep-sea sedds
Goldberg and Koide, 1958	Ionium-thorium chronology in sedds; Pacific
Goldberg and Koide, 1962	Geochronological studies of deep-sea sedds; Io/Th method
Goldberg and Picciotto, 1955	Thorium in Mn nodds
Greenslate, Frazer, and Arrhenius, 1973	Origin and deposition of selected transition elements in seabed

- Heye, 1969 U, Th, Ra in ocean water and deep sea seds
- Heye and Beiersdorf, 1973 Radioactive and magnetic investigations of Mn nods for ascertaining growth rate or age determination
- Holmes, Goodell, and Osmond, 1967 Geochronology; South Pacific
- Holmes, Osmond, and Goodell, 1966 Geochronology of Eltanin cores; South Pacific (Antarctic)
- Immel, 1974 Origin of micromanganese nods determined from  $U^{234}/U^{238}$  ratios
- Jenne and Wahlberg, 1968 Radio-ion sorption; role of certain stream-sediment components
- Koczy, 1949 Th in sea-water and marine seds
- Koide and Goldberg, 1965  $U^{234}/U^{238}$  ratios in seawater
- Krishnaswami, et al., 1972 Beryllium-10; dating Mn nods; ocean
- Kroll, 1954 Ra; age of seds; ocean
- Kroll, 1955 Ra in Mn crusts
- Ku, 1965 Evaluation of  $U^{234}/U^{238}$  method as tool for dating pelagic seds
- Ku and Broecker, 1967a U, Th and Pa in Mn nod
- Ku and Broecker, 1967b Growth rates of Mn nods; ocean
- Ku and Broecker, 1969 Radiochem; Mn nods; ocean
- Ku and Glasby, 1972 Radiometric evidence for rapid growth of shallow continental margin Mn nods
- Kurbatov, L. M., 1935 Radioactivity of Fe-Mn formations; seas and lakes; USSR
- Kurbatov, L. M., 1936 Age of Fe-Mn concretions
- Kurbatov, L. M., 1937 Radioactivity of Fe-Mn formations; seas and lakes; USSR
- Kurbatov, L. M. and Ermolaev, 1937 K voprosu o radioaktivnosti i khimicheskom sostave gruntov Karskogo Morya



Lalou and Brichet, 1972	Significance of radiochem measurements for evaluation of Mn nod growth rate
Lalou, Brichet, and Ranque, 1973	Nods found at sed surface; possibility of formation contemporaneously with sedimentation
Lalou, Delibrias, <u>et al.</u> , 1973	C <sup>14</sup> at center of two Mn nods from Pacific; C <sup>14</sup> and Th <sup>230</sup> ages
Ljunggren, 1955a	Chem and radioactivity of Mn and Fe bog ores
Matthews, 1954	Investigation of Th content of Mn nods using nuclear plates
Miyake and Sugimura, 1961	Io-Th chronology of deep-sea seds of NW Pacific
Mo, Suttle, and Sackett, 1973	U in seds; marine
Moore, W. S., 1969	Oceanic concentrations of Ra <sup>228</sup>
Moore, W. S., 1973	Accum rates of Mn crusts on rocks; ocean
Moore, W. S. and Sackett, 1964	U and Th series inequilibrium in seawater
Morgenstein, 1972c, 1973a	Sed diagenesis and rates of Mn accretion; Waho Shelf, Hawaii
Nikolayev and Yefimova, 1963	Age of Fe-Mn concretions; Indian and Pacific Oceans
Nikolayev and Efimova, 1964	Radioactive elements in Fe-Mn concretions
Otgonsuren, <u>et al.</u> , 1969	Remote transuranium elements in Fe-Mn concretions
Pettersson, 1943	Mn nods and chronology of ocean floor
Pettersson, 1955	Mn nods and oceanic Ra
Reynolds, P. H. and Dasch, 1970	Pb isotopes in marine Mn nods
Reynolds, P. H. and Dasch, 1971	Pb isotopes in marine Mn nods and ore-Pb growth curve

Sackett, 1964	Measured deposition rates of marine seds; implications for accum rates of extra-terrestrial dust
Sackett, 1966	Mn nods; Th <sup>230</sup> /Pa <sup>231</sup> ratios
Schornick, 1972	U and Th isotope geochem in Fe-Mn concretions from Southern Ocean
Scott, M. R., Scott, Rona, <u>et al.</u> , 1974	Rapidly accum Mn deposit; median valley, Mid-Atlantic Ridge
Somayajulu, 1967	Beryllium-10 in Mn nod
Somayajulu and Church, 1973	Ra, Th, U isotopes in interstitial water from Pacific sed
Somayajulu and Goldberg, 1966	Th and U isotopes in sea water and seds
Somayajulu, Heath, <u>et al.</u> , 1971	Rates of accum of Mn nods and sed; Equat Pacific
Tatsumoto and Goldberg, 1959	Aspects of marine geochem of U
Volchok and Kulp, 1957	Ionium method of age determination
von Buttlar and Houtermans,	Deep-sea Mn nods; photographic determination of activity
Wiggins, <u>et al.</u> , 1970	Neutron capture gamma-ray analysis of Mn nods using <sup>252</sup> Cf

## S E C T I O N 2 2

### INSTRUMENTAL AND ANALYTICAL TECHNIQUES FOR STUDYING NODULES

This section lists reports emphasizing the use of instrumental and analytical techniques for collecting and studying ferromanganese accumulations and associated geological materials, including age-dating techniques, x-ray diffraction analysis, optical and electron microscopy, neutron activation analysis, Mossbauer spectroscopy, differential thermal analysis, and various chemical analysis methods, as well as other less widely used techniques.

## INSTRUMENTAL AND ANALYTICAL TECHNIQUES FOR STUDYING NODULES

- |                                 |  |
|---------------------------------|--|
| Addy and Ewing, 1974            | New box corer design; Mn nod distrib<br>in sed column  |
| Agioritis, 1969                 | DTA; infra-red spectroscopy; Mn<br>minerals  |
| Albee and Chodos, 1970          | Semiquantitative electron microprobe<br>determinations of $Fe^{+2}/Fe^{+3}$ and $Mn^{+2}/$<br>$Mn^{+3}$ in oxides and silicates;<br>application to petrol problems |
| Albee, <u>et al.</u> , 1968     | Semiquantitative electron microprobe<br>determinations of $Fe^{+2}/Fe^{+3}$ and $Mn^{+2}/$<br>$Mn^{+3}$ in silicates; application to<br>petrol problems            |
| Andermann, 1972a                | Spectroscopic analysis; Mn nodds;<br>Pacific   |
| Andermann, 1972b                | Spectroscopic characterization;<br>molecular properties of Mn nodds;<br>Pacific  |
| Angino, <u>et al.</u> , 1971    | Electron spin resonance; Mn in water   |
| Anonymous, 1969a                | Simple nod analysis  |
| Babcan, 1960                    | Determination of Mn oxides of various<br>valencies   |
| Barnhisel, <u>et al.</u> , 1969 | X-ray fluorescence; Fe and Mn in soils<br>and concretions  |
| Bei and Cheo, <u>1966</u>       | Oxalate method; influence of acidity<br>and light; analysis of pyrolusite  |
| Belyayev and Gordeyev, 1972     | Atomic absorption; Mn, Ag, Pb, and Cd<br>in seawater suspension  |
| Benes and Garba, 1966           | Radiotracer; Mn adsorption in glass<br>from dilute aqueous solution  |
| Bhandari, <u>et al.</u> , 1971  | Rapid beta gamma coincidence; natural<br>radio-nuclides in marine deposits   |
| Bode, <u>et al.</u> , 1962      | Phase analysis of $MnO_2$  |

- Bowser, et al., 1970 Electron probe and x-ray study; Fe-Mn nodds; freshwater; Wisconsin and Michigan
- Brenet, et al., 1963 Analytical study and thermodynamics of varieties of MnO<sub>2</sub>
- Brewer and Spencer, 1971 Colorimetric determination; Mn in anoxic waters
- Brown, B. A., 1972 Low-temperature crushing; Mn nodds
- Burns, R. G., 1966 Electron-probe; trace elements in Mn nodds
- Burns and Fuerstenau, 1966 Electron-probe; elements in Mn nodds
- Buser and Graf, 1955a Radiochem studies; ion- and isotope-exchange reactions of MnO<sub>2</sub> and manganites
- Butler and Thirsk, 1952 Cryptomelane modification of MnO<sub>2</sub> prepared in absence of potassium; electron diffraction evidence for existence and fine structure
- Caillère and Kraut, 1954 Thermal behavior of some manganiferous minerals
- Cann and Winter, 1971 X-ray fluorescence; suspended sed in seawater
- Carpenter and Wakeham, 1973 Mössbauer studies; marine and fresh water Mn nodds
- Carpenter, et al., 1972 Thermomagnetic behavior of Mn nodds
- Carr and Gordon, 1970 Mn analysis of natural waters; effect of storage
- Chaffee, 1970 Atomic absorption; acid-soluble and total Mn in geological and botanical materials
- Chakravarti and Dhar, 1927 Freundlich adsorption formula; adsorption of electrolytes by Mn dioxide
- Chao and Sanzolone, 1973 AA spectrophotometric determination of microgram levels of Co, Ni, Cu, Pb, Zn; soil and sed extracts containing large amounts of Mn and Fe

- Chester and Hughes, 1967 Chem technique for separation of Fe-Mn minerals, carbonate minerals, and trace elements from pelagic seds
- Chow and McKinney, 1958 Mass spectrometric determination of Pb in Mn nods
- Coey and Readman, 1973 Characterization and magnetic properties of natural ferric gel
- Coey, et al., 1974 Fe compounds in lake seds
- Cole, et al., 1947 X-ray diffraction study of MnO<sub>2</sub>
- Costabile and Perron, 1971 Diatomite filters end Mn problems
- Crececius, et al., 1973 Magnetism and magnetic reversals in Fe-Mn nods
- Cronan and Tooms, 1968 Microscopic and electron probe investigations; Mn nods; NW Indian Ocean
- Dachs, 1962 Neutron diffraction determination of hydrogen position in manganite
- Dachs, 1963 Neutron and x-ray studies of manganite
- Dasch, Dymond, and Heath, 1971 X-ray diffraction, K-Ar dating and isotopic analysis; chem of Fe-rich sed; East Pacific Rise
- Dasch, Heath, and Dymond, 1971 Isotopic analysis of metalliferous sed; East Pacific Rise
- Delfino and Lee, 1969 Colorimetric determination; Mn in lake waters
- deWolff, 1959  $\gamma$ -MnO<sub>2</sub> diffraction patterns; interpretation
- Dolezal, et al., 1963 Titrimetric analysis; Mn in ores and metals
- Duffy, et al., 1972 Neutron capture gamma ray studies; geological materials
- Dunham and Glasby, 1970 Electron probe; Mn nods

Dunham and Glasby, 1974	Petrographic and electron microprobe investigation; some deep- and shallow-water Mn nodds
Ehrlich, H. L., 1973a	Biology of Fe-Mn nodds; effect of freezing on viable nod flora; check on identification of MnO <sub>2</sub> -reducing cultures
Eklund, 1974	Microprobe study of metalliferous sed components
Elderfield and Glasby, 1973	Infrared spectra of Mn nodds and Fe-Mn seds
Endo and Koroki, 1960	EDTA titration; Mn in Mn ore
Estep, 1973a,b	Infra-red micro-analysis; formation history of Fe-Mn deposits
Ewing, Hayes, and Thorndike, 1967	Corehead camera; measurement of currents and core orientation
Faulring, 1962	X-ray analysis; Cuban todorokite
Faulring, 1965	Unit cell determination and thermal transformations of nsutite
Fein and Morgenstein, 1973, 1973	Microprobe; Mn crusts; ocean; Hawaii
Fewkes, 1973	SEM; external and internal features of marine Mn nodds; implications in nod origin
Finkelman, Matzko, <u>et al.</u> , 1972	SEM study; Mn minerals in geodes; Chihuahua, Mexico
Fleischer, R. L., <u>et al.</u> , 1968	Search for multiply charged Dirac magnetic poles
Fomina, 1967	Determination of Mn of different valency
Friedrich, Kunzendorf, and Plüger, 1973	EDX-technique; geochem of Mn nodds; Pacific
Friedrich, Rosner, and Demirsoy, 1969	Ore-microscopy and micro-analysis; Mn concretions; Pacific
Fukai, 1968	Spectrophotometric determination; Co in seawater with Mn dioxide

Gager, 1968	Mössbauer spectra; Fe-Mn nodds; ocean
Gallaher, Perkins, and Radcliffe, 1973	Electron microprobe; soil concretions
Georgescu and Nistor, 1970	Study of Fe chem bond by Mössbauer effect; Fe-Mn concretions; Black Sea
Georgescu, <u>et al.</u> , 1973	Mössbauer spectroscopy of Mn nodds; Black Sea
Giovanoli, Bühler, and Sokolowska, 1973	Electron microscopy and x-ray diffraction; synthetic lithiophorite
Glasby, 1972i	Oxygen isotopes; paleoenvironmental study of Mn nodds; marine
Goncharov, <u>et al.</u> , 1973	Nuclear magnetic resonance investigation; Fe-Mn concretions; Pacific
Goto, <u>et al.</u> , 1962	Rapid colorimetric determination; Mn in waters containing Fe
Greenslate, Fitzgerald, <u>et al.</u> , 1972	Computerized chem mapping of ocean floor
Henriksen, 1966	Formaldioxime method; Mn in water containing Fe
Herzenberg, 1969	Mössbauer spectrometry; determinative mineralogy
Herzenberg and Riley, 1969	Mössbauer spectra; Fe-Mn nodds; marine
Heye and Beiersdorf, 1973	Radioactive and magnetic investigations of Mn nodds; growth rate or age determination
Hooke, <u>et al.</u> , 1969	Electron probe; desert varnish
Hryniewicz, <u>et al.</u> , 1970a,b	Mössbauer effect in Pacific Ocean Fe- Mn nodds
Hryniewicz, Pustówka, <u>et al.</u> , 1972a	Mössbauer study of Fe-Mn nodds at high temperatures
Hryniewicz, Pustówka, <u>et al.</u> , 1972b	Mössbauer effect analysis of Pacific Fe-Mn nodds



- International Organization for Standardization, 1963  
Chem analysis methods; Mn ores; hygroscopic moisture
- Johnson, C. E. and Glasby, 1969  
Mössbauer effect; particle size in microcrystalline Fe-Mn nods
- Joyner and Finley, 1966  
Determination of Mn and Fe in sea water; atomic absorption
- Kanta Rao and Chowdhury, 1969  
Photometric determination; Mn in ores and alloys
- Kawashima, et al., 1961  
Neutron activation; La, Sm and Eu in Mn nods
- Kollwentz, 1973a,b  
Exploration techniques; marine nods; Valdivia
- Krupyanskii and Suzdalev, 1973  
Magnetic properties of ultrafine Fe oxide particles
- Kulp and Perfetti, 1950  
Thermal study of Mn oxide minerals
- Kulp and Trites, 1951  
DTA; natural hydrous ferric oxides
- Kundig, et al., 1966  
Mössbauer effect; properties of supported small  $\alpha$ -Fe<sub>2</sub>O<sub>3</sub> particles
- Lalou, Brichet, and LeGressus, 1973  
SEM and microanalysis study of Mn nod; implication for mode of nod formation
- Ljunggren, 1955b  
DTA and x-ray examination; Fe and Mn in bog ores
- Lonsdale, Southard, and Hollister, 1971  
Flume studies; threshold velocities for red clay erosion; North Pacific
- Lueschow, 1973  
Nondispersive x-ray spectrometric analysis; Mn nods
- Lueschow and Kraft, 1973  
Nondispersive x-ray spectrometric analysis; Mn nods; Pacific
- MacKenzie, et al., 1971  
Oxides of Fe, Al, Mn; electron-optical investigation
- Margolis and Glasby, 1972, 1973  
SEM; micro-laminations in Mn nods; marine
- Matthews, 1954  
Investigation of Th content of Mn nods using nuclear plates

- McMurdie, 1944  
Microscopic and diffraction studies on dry cells and their raw materials
- Merlini, et al., 1965  
Activation analysis; Mn in molluscs; Lake Maggiore
- Moore, W. S., et al., 1973  
Trace element extraction from natural waters using Mn-impregnated acrylic fibers
- Mottola and Harrison, 1971  
Kinetic methods; Mn (II) in solution
- Mukherjee, 1959a  
X-ray studies; psilomelane and cryptomelane
- Mukherjee, 1959b  
X-ray study of Mn minerals
- Naganna and Bouška, 1963  
X-ray study of woodruffite; Sandur ore deposits, Mysore State, India
- Nichol and Phillips, 1965  
Measurement of spectral reflectivity of Mn oxides
- Okada, Minakuchi, and Shima, 1972  
Thermal studies; Fe-Mn phase; Mn nodules
- Okada, Okada, and Shima, 1973  
Magnetic properties and Mössbauer effect; Mn nodules
- Omerod, 1966  
Method to detect oxidized Mn in particles on membrane filters
- Ostroumov and Volkov, 1962  
Cinnamic acid; separation of Ti, Zr and Th from Mn, Ni, Co and Zn
- Ozima, 1967  
Magnetic properties of Mn nodules associated with dredged submarine basalts
- Patterson, 1972  
Inspection of Mn deposits in deep water
- Perfil'ev, et al., 1965  
Capillary microscopy; role of microorganisms in formation of Fe-Mn deposits
- Pernet, et al., 1973  
Mössbauer effect; characterization and study of a new variety of high pressure FeOOH
- Pribil and Hornychova, 1950  
Colorimetric determination of Mn; use of complexones

Ramsdell, 1932	X-ray study of psilomelane and wad
Reid, <u>et al.</u> , 1974	Ra extraction from sea water; efficiency of Mn-impregnated acrylic fibers
Reynolds, G. F. and Tyler, 1964	Separation of trace metals by MnO <sub>2</sub> "collection" method
Robertson, <u>et al.</u> , 1968	Neutron activation; elements in seawater, marine organisms, and seds
Rona, Hood, <u>et al.</u> , 1962	Activation analysis; Mn and Zn in seawater
Schossberger, 1940a,b	X-ray examination of natural and synthetic MnO <sub>2</sub>
Schutz and Turekian, 1965b	Neutron activation; distrib of trace elements in seawater
Schwarz, 1968	Thermomagnetic properties of banded manganiferous sed; Mid-Atlantic Ridge
Seabed Assessment Program, 1974	Workshop on Mn nod mineralogy and geochem methods
Sinkankas, 1968	High pressure epoxy impregnation of porous materials for thin section and microprobe analysis
Smitheringale, 1929	Etching tests and x-ray examination; Mn minerals
Sorem, 1960	XRD technique for small samples
Sorem and Foster, 1972b	Macroprobe x-ray analysis and specimen distance effect
Sorem and Foster, 1973	Mineralogy, chem and optical procedures; Mn nods
Sparks, 1971	Charged particle activation; light elements in Mn nods
Sparks and Glasby, 1973	Application of charged particle activation analysis to some light elements; marine Mn nods
Spiess, 1972	Fine-scale survey technology; Fe-Mn deposits; ocean

- Takeda, 1974  
Investigations of deep sea mineral resources; NW Pacific
- van der Giessen, et al., 1968  
Mössbauer effect; study of constitution and freezing behavior of Fe oxide-hydrate gels
- Vaux, 1937  
X-ray studies of pyrolusite (including polianite)
- Vink, 1970  
Determination of harmful trace elements in Mn dioxide for dry cell use
- von Heimendahl, et al., 1973  
Transmission electron microscope study; deep-sea Mn nodds
- Wadsley, 1950a  
Synthesis of hydrated Mn minerals
- Wakeham and Carpenter, 1973  
Electron spin resonance spectra of Mn nodds
- Wiggins, et al., 1970  
Neutron capture gamma-ray analysis; Mn nodds; marine
- Wildeman, 1969  
Electron paramagnetic resonance; distrib of Mn<sup>+2</sup> in carbonates
- Willis, et al., 1964  
Spectrochem estimation of thallium in granites and Mn nodds
- Wilson, D. A., 1964  
Titrimetric and spectrophotometric; oxidizing capacity of Mn compounds
- Winterhalter and Siivola, 1967  
Electron microprobe; distrib of Fe, Mn, and P in concretions; Gulf of Bothnia, N Baltic
- Wogman, et al., 1973  
In situ analysis; elements in Mn nod fields; ocean
- Wogman, Rancitelli, et al., 1973  
In situ analysis; elements in Mn nod fields
- Wolfe, L. A. and Zeitlin, 1970  
X-ray fluorescence spectroscopy; total Mn in rocks and marine sed
- Woo, 1973  
Scanning electron micrographs; marine Mn micro- and pebble-sized nodds and freshwater Mn nodds

Yanchuk, 1968

X-ray spectroscopy; valence of Mn in minerals

Yatsimirskiy, et al., 1971

Determination of microquantities of Mn and Cu in small samples or marine suspension; Baltic and Atlantic

Yuen, 1958

Determination of traces of Mn with leucomalachite green



S E C T I O N 2 3

COSMIC SPHERULES IN NODULES

This section lists articles on meteoritic particles reported in Mn-nodules and associated sediments.

## COSMIC SPHERULES IN NODULES

- |                                  |   |
|----------------------------------|---|
| Barker and Anders, 1968          | Accretion rates of cosmic matter from Ir and Os in sed; ocean                                   |
| Brunn, <u>et al.</u> , 1955      | Magnetic particles found by raking deep-sea bottom  |
| Finkelman, 1970                  | Magnetic particles from Mn nods; origin from meteorites   |
| Finkelman, 1972                  | Mn nods and cosmic spherules; relationship  |
| Finkelman and Commeau, 1971      | Analysis of extraterrestrial silicate particles from deep-sea Mn nods                           |
| Garrety, 1970                    | Magnetic minerals in pelagic sed  |
| Hunter and Parkin, 1960          | Cosmic dust in recent deep-sea sed  |
| Jedwab, 1970                     | Cosmic spherules in Mn nods   |
| Jedwab, 1971                     | Carbon particles in deep-sea Mn nods  |
| Laevastu and Mellis, 1955        | Extraterrestrial material in deep-sea deposits  |
| Murray and Renard, 1891          | Mn nods; deep-sea deposits; HMS <u>Challenger</u>   |
| Parkin and Tilles, 1968          | Influx measurements of extraterrestrial material  |
| Pettersson, 1960                 | Cosmic spherules and meteoritic dust  |
| Pettersson and Fredriksson, 1958 | Magnetic spherules in deep-sea deposits   |
| Sackett, 1964                    | Measured deposition rates of marine sed; implications for accum rates of extra-terrestrial dust |



## S E C T I O N 2 4

### a - ECONOMIC POTENTIAL OF MANGANESE NODULES

This section lists articles dealing with the economic potential of marine and freshwater manganese nodules, the formation and progress of nodule mining companies and consortia, and discussions of the distribution and occurrence of ore-grade nodules.

### b - NODULE EXPLORATION AND MINING

This section lists articles describing the techniques and results of manganese nodule exploration and mining, and activities of nodule mining groups.

### c - METALLURGICAL PROCESSING OF NODULES

This section lists articles describing the requirements for, and the test results of, the metallurgical processing of nodules.

## ECONOMIC POTENTIAL OF MANGANESE NODULES

Amann, 1973a,b	Intl organization to explore and utilize mineral resources; ocean
Anderson, E. V., 1974	World's nations scramble for sea's riches
Anonymous, 1965	Undersea mining
Anonymous, 1966	Mn nods cover seafloor
Anonymous, 1968	Ocean-bottom minerals
Anonymous, 1969b	Mn nods and phosphorite
Anonymous, 1970a	Deep Sea Ventures, Inc.
Anonymous, 1970b	Nod mining becomes reality
Anonymous, 1970f	German firm joins Deep Sea Ventures exploratory program
Anonymous, 1971a,b,j	Mn nods; Kauai Channel deposits
Anonymous, 1971h	What Russia knows about Pacific minerals
Anonymous, 1972b	Environmental quality and seabed resources
Anonymous, 1972c	Deep ocean mining is surfacing
Anonymous, 1973a	Ocean mining activity on several fronts
Anonymous, 1973c	Japan pushes for deep-ocean venture
Anonymous, 1973e	Race to mine ocean's riches
Anonymous, 1973g	Deepsea ventures into Mn
Anonymous, 1973h	Japanese deepen ocean mining interest
Anonymous, 1973j	Harvest of ocean nods nears commercialization
Anonymous, 1973l	Metals from sea; Hawaii as center
Anonymous, 1973m	UNCTAD studies Co from Mn nods

Anonymous, 1973n	West Germany pushing ocean mining
Anonymous, 1974a	Kennecott considers nods competitive
Anonymous, 1974d	Deepsea's \$20-million venture
Archer, 1970	Sub-sea minerals and environment
Archer, 1973	Progress and prospects of marine mining
Bäcker and Schoell, 1974	Concentration of elements for raw materials in marine environment
Barnes, B. B., 1972	Deep-sea mining
Barten and Shaw, 1969	Monte Carlo simulator for predicting feasibility of deep ocean mining operations
Bezrukov, 1971a	Geologic structure and mineral resources; Pacific Ocean bottom
Bollow, 1971	Economic effects: ocean mining
Boström, 1967c	Elements of economic interest in deep sea sed; origin of
Brooke and Prosser, 1969	Mn nods: Cu and Ni source; mineralogical assessment and extraction
Brooks, D. B., 1966	Low-grade and unconventional sources of Mn
Brooks, D. B., 1968	Mn nods; world resource; ocean
Brooks, D. B. and Lloyd, 1968	Mineral economics and the ocean
Burk, 1973	Mineral resources of the oceans; SW Pacific
Callender, 1968	Mn; mineral resource; Great Lakes
Callender, 1970	Economic potential of Fe-Mn nods; Great Lakes
Calvert and Price; 1970a	Mn nods; promise and problems
Christy, 1970	Marigenous minerals; resources
Clauss, 1972	Economic aspects of mining Mn nods

Cloud, 1968	Mineral resources; ocean
Craven, 1972	Hawaii; seabed resources and law
Cruickshank, 1964	Ocean mining; methods of mineral recovery
Cruickshank, 1972a	Environmental and technological considerations in exploration and exploitation of Mn nods
Cruickshank, <u>et al.</u> , 1968	Offshore mining - present and future
Davin, 1972	Resource geology; IDOE research programs
DeHuff, 1970	Mn; BuMines handbook
Dorstewitz, 1971	Ocean mining of Co, Cu, Mn, Ni
Dorstewitz, 1972	Prospects for ocean mining of Mn nods
Doumani, 1971	Exploiting seabed resources
Drechsler, 1972	Mn nod industry
Drechsler, 1973	Exploitation of sea; preliminary cost-benefit analysis of nod mining and processing
Dupuy, 1975	Prospects for economic and legal conquest of the seas
Emery, 1967	Mineral resources; continental shelf
Ensign, 1966	Economic barriers delay undersea mining
Firth, 1969	Mineralogy and chem of Mn nods, seds, and seawater; economic potential; survey and sampling techniques; Pacific and worldwide
Flipse, 1969b	Economic recovery of Mn nods
Flipse, 1972	Ocean mining--the sleeping giant
Gaskell, 1965	Economic potential of oil and other resources; offshore marine
Glasby, 1974a	Exploitation of Mn nods; South Pacific

Gordon, H. S., 1971	Timetable quickens for mining ocean nodds
Gurney, 1963	Mn nodds; mineral wealth on the ocean floor
Halbach, 1971	Concretionary deposits as mineral resources; ocean
Hammond, 1974a	Mn nodds; mineral resources on the deep seabed
Hammond, 1974b	Mn nodds; deep sea mining
Hassialis, 1973	Economic evaluation; Fe-Mn deposit
Herbich, 1969	Ocean floor mining
Hering, 1971a	Mn concretions from deep-sea; possible source of non-ferrous metals
Hering, 1971b	Metals from deep-sea ores; results and problems of Mn nod research
Horn, D. R., Horn and Delach, 1973a	Mn nodds; metal values and mining sites; ocean
Hubred, 1970a	Economy of Mn nodds
Ivanov, 1973	Possibilities of exploring oceans for mineral resources
James, 1968	Mineral resources potential of the deep oceans
Kaufman, A., 1970	Economics of ocean mining
Kaufman, A. and Handsman, 1969	Ocean mining - today and tomorrow; the decade ahead, 1970-1980
Kaufman, R. and Greenwald, 1972	Mn nod mining; technical progress and law
Kaufman, R. and Rothstein, 1970	Ocean mining
Kraft, 1969	Nod riches on ocean floor
Lampietti and Marcus, 1974	Computer model predicts acceptable risks for commercial nod mining projects

Laque, 1971	Ocean mining; prospects
Loftas, 1970	Ocean mining; profitable?
McIlhenny, 1966	Oceanic utilization
McKelvey and Wang, 1970	World mineral resources and map; ocean
McKelvey, <u>et al.</u> , 1969	Mineral resources and problems in development; ocean
Mead and Sorenson, 1968	Externalities in ocean mineral resource development
Meiser and Muller, 1973a,b	Mn nods - a further resource to meet mineral requirements?
Mero, 1959	Mining and processing of Mn nods; ocean
Mero, 1960b	Mineral resources on ocean floor
Mero, 1961	Economics of deep sea mining
Mero, 1964	Mineral wealth; ocean
Mero, 1965	Mineral resources; ocean
Mero, 1966b	Ocean mining; future
Mero, 1967	Marine research and resources
Mero, 1971a	Ocean mining is alive and well and living at sea
Mero, 1971b	Oceanic mineral resources and current developments in ocean mining
Mero, 1972a	Economic value of Mn nod deposits; ocean
Mero, 1972b	Economic value of Mn nod deposits; ocean
Mero, 1972c	Future promise of mining in ocean
Moore, J. R., 1970	Mn-rich pellets; mineral resource; Green Bay, Lake Michigan
Moore, J. R., 1972	Exploitation of ocean minerals resources - perspectives and predictions

Morgenstein and Andrews, 1971	Mn resources; Hawaii
Numata, 1968	Soon sweep seafloor for valuable minerals
Overly, 1972	Resource allocation for ocean mining
Pings and Paist, 1970	Minerals from oceans
Potter, 1969	Economic potentials of Antarctic
Pratt, R., 1971	Mn; supply-demand position
Rigg, 1974	Minerals from the sea
Rothstein, 1970	Nod mining; ocean
Rothstein and Kaufman, 1973	Approaching maturity of deep ocean mining--pace quickens
Shapley, 1973	Ocean technology; race to wealth; problems
Sorem and Foster, 1973	Mineralogy, chem and optical study; growth and economic potential of Mn nodules; ocean
Sorensen and Mead, 1968	Cost: Mn nod resource development; ocean
Spangler, 1970	National interest; cupro-nickel nodules; ocean
Stratton, 1969	Our nation and the sea
Summerhayes, 1967b	Economic mineral deposition; marine; New Zealand
Swann, 1974	Mn nodules; potential as future mineral resource
Takebayashi, 1972	Marine science and technology; present and future; Japan
Taylor, D. M., 1971	Nodes become valuable
Tinsley, 1973	Commercial nodules; Miocene-age Pacific Tertiary System looks best
Tooms, 1967a	Marine minerals

Tooms, 1967b	Inorganic mineral potential; exploration; ocean
UNESCO, 1970	Oceanic exploration and research; programme outline
United Nations General Assembly, 1971	Possible impact of sea-bed mineral production on world markets
United Nations General Assembly, 1972	Possible economic implications of mineral production from intl sea-bed area
Vasil'chikov, <u>et al.</u> , 1968	Fe-Mn nods; ocean; production of Co, Ni, Mn and Cu
Victory, 1973	Metals from deep sea
Vozza, 1971	Ocean bottom mineral resources for future
Walthier, 1973	Present status and future potential of mineral resources in marine environment
Wilson, T. A., 1965	Undersea mining
Wojciechowski, 1972	Technology and economics; mining Mn nods; marine
Wright and Williams, 1974	Mineral resources of Antarctica



## NODULE EXPLORATION AND MINING

Amann, 1973a,b	Intl organization to explore and utilize mineral resources; ocean
Anonymous, 1965	Undersea mining
Anonymous, 1970a	Deep Sea Ventures, Inc.
Anonymous, 1970b	Nod mining becomes reality
Anonymous, 1970c	Japanese bucket dredge mines nods
Anonymous, 1970e	Ocean mining; dredging
Anonymous, 1970f	German firm joins Deep Sea Ventures exploratory program
Anonymous, 1972a	Mining; bottom crawlers; dredging
Anonymous, 1972c	Deep-ocean mining is surfacing
Anonymous, 1973a	Ocean mining activity on several fronts
Anonymous, 1973c	Japan pushes for deep-ocean venture
Anonymous, 1973d	Probing Hughes' role in ocean mining
Anonymous, 1973e	Race to mine ocean's riches
Anonymous, 1973f	Hughes ocean mining ship set to go
Anonymous, 1973g	Deepsea ventures into Mn
Anonymous, 1973h	Japanese deepen ocean mining interest
Anonymous, 1973i	Hughes deep ocean mining vessel delivered
Anonymous, 1973k	Japan tests ocean mining system
Anonymous, 1973n	West Germany pushing ocean mining
Anonymous, 1974b	Kennecott forms nod research group
Anonymous, 1974c	Hughes <u>Glomar Explorer</u> begins sea tests of mining systems

Anonymous, 1974d	Deepsea's \$20-million nod venture
Anonymous, 1974f	Seafloor mining project planned
Anonymous, 1974g	Ocean mining faces environmental hurdle
Anonymous, 1975	Deep-ocean mining takes a step ahead
Archer, 1973	Progress and prospects of marine mining
Ball, 1967	Lifting nods
Barnes, B. B., 1972	Deep-sea mining; role of NOAA's marine minerals technology center
Barten and Shaw, 1969	Simulator for deep ocean mining
Bascom, 1967	Mining ocean depths
Beiersdorf and Bungenstock, 1973	Seismic reflection for Mn nod exploration with <u>Valdivia</u> ; NE Equat Pacific
Bilodid, 1973	Present-day methods for deep-water exploitation of Fe-Mn concretions
Caldwell, 1971	Deep Sea Ventures readying its attack on Pacific nods
Covey, 1970	Ocean mining system
Cruickshank, 1972a	Environmental and technological considerations in exploration and exploitation of Mn nods
Dorstewitz, 1971	Ocean mining of Co, Cu, Mn, Ni
Dorstewitz, 1972	Prospects for ocean mining of Mn nods
Dürbaum and Schlüter, 1974	Possibilities of seismic reflection for Mn nod exploration
Emery, 1966	Geological methods for locating mineral deposits on ocean floor
Firth, 1969	Mineralogy and chem of Mn nods, seds, and seawater; economic potential; survey and sampling techniques; Pacific and worldwide

Flipse, 1969a	Engineering; ocean mining
Flipse, 1969b	Economic recovery of Mn nods
Flipse, 1972	Ocean mining
Flipse and Kaufman, 1971	Progress in mining Mn nods from deep ocean
Gordon, H. S., 1971	Timetable quickens for mining ocean nods
Hammond, 1974b	Mn nods; prospects for deep sea mining
Herbich, 1969	Ocean floor mining
Hering, 1971b	Metals from deep-sea ores; results and problems of Mn nods research
Hering, 1971c	Detecting Mn deposits; ocean
Hering, 1971d	Future mineral prospecting and exploration; ocean
Hess, 1965	Ocean: mining's newest frontier
Hinz and Schlüter, 1973	Results of seismic reflection measurements; <u>Valdivia</u> cruise Manganknollen I; Equat Pacific
Horn, D. R., Horn and Delach, 1973b	Mn nods; metal values and mining sites; ocean
Issacs, 1974	Dredging for bulk samples of Mn nods
Kaufman, R., 1974	Mn nod ore body; selection and sizing of tracts
Kollwentz, 1973a,b	Techniques/experiences; marine nod exploration; <u>Valdivia</u>
Kuroda, 1971	Collecting test of Mn nods
La Motte, 1970	Deep Sea Ventures pilot run
Lockwood, 1964	Engineering; mineral recovery; ocean
Londenberg, 1973	Ocean mining ship
Masuda, 1972	Mn nod exploitation programs

Masuda, <u>et al.</u> , 1971	Continuous line bucket system for deep-sea mining
Mero, 1959	Mining and processing of Mn nodules; ocean
Mero, 1966a	Exploration for mineral deposits; ocean
Mero, 1968	Proposal for seafloor nod mining operation
Mero, 1971a	Ocean mining is alive and well
Mero, 1971b	Oceanic mineral resources; current developments in ocean mining
Mero, 1972d	Recent concepts in undersea mining
Moore, J. R. and Cruickshank, 1973	Exploration of Fe-Mn deposits; marine
Morgenstein, 1973b	Origin and distrib of Mn nodules in Pacific and prospects for exploration
Niblock, 1969	Offshore mining system
Pearson, 1966	Mining industry's role in development of undersea mining
Ralph, 1972	Ocean mining systems
Richter, 1973	Digitally recorded seismic for Mn nod exploration
Richter and Schlüter, 1973	<u>Valdivia</u> exploration for Mn nodules, 1973; seismic reflection survey
Roels, 1972	Mn nod mining; environment
Rothstein, 1970	Nod mining; ocean
Rothstein and Kaufman, 1973	Approaching maturity of deep ocean mining--pace quickens
Schatz, 1971	Sampling and occurrence of Mn nodules
Stechler and Nicholas, 1972	Recovery of Mn nodules; ocean
Steinert, 1970	First big test in deep-sea mining succeeded

Tooms, 1967b	Inorganic mineral potential; exploration; ocean
Tooms, 1968	Applied geochem mineral exploration; marine
Tooms, 1971	Marine geochem exploration
Weber, H., 1973	Exploration for Mn nods in Pacific
Welling and Cruickshank, 1966	Review of available hardware needed for undersea mining
Wilson, T. A., 1965	Undersea mining
Wojciechowski, 1972	Technology and economics; mining Mn nods; marine

## METALLURGICAL PROCESSING OF NODULES

- Agarwal, et al., 1975                      Processing of ocean nodules; technological and economic review
- Anonymous, 1971e                              Deep Sea Ventures; nod metals separating process
- Anonymous, 1971k                              Pure metals from nodules; ocean
- Anonymous, 1973b                              Processing no problem for ocean mining
- Anonymous, 1974b                              Kennecott forms nod research group
- Barbier, 1973                                  Treatment of nodules
- Beck and Messner, 1970                        Cu, Ni, Co, Mo recovery from deep-sea nodules
- Brooke, 1968                                  Texture and hydrometallurgical processing of Mn nodules
- Brooke and Prosser, 1969, 1970               Mn nodules: Cu and Ni source; mineralogical assessment and extraction
- Brooks, P. T. and Martin, 1971               Processing Mn nodules; ocean
- Buckenham, 1961                              Beneficiation of Mn ores; low grade ore; Fiji
- Cardwell, 1973                                Ocean nodules; extractive metallurgy
- Chang and Silvestri, 1974                     Mn nodules as demetalation catalysts
- Drechsler, 1973                                Exploitation of sea: preliminary cost-benefit analysis of nod mining and processing
- Fuerstenau, et al., 1967                      Leaching of Mn nodules; ocean
- Fuerstenau, et al., 1973                      Metals from sea floor Mn nodules; characterization and extraction
- Gefvert, 1973                                  Mn nod leach liquor; solvent extraction
- Gerard, 1972                                  Processing marine minerals

Grice and Hancock, 1972	Processing Mn pavement from San Pablo Seamount
Han, 1971	Geochem and extraction of metals from Mn nods; ocean
Han and Fuerstenau, 1973	Metal ions; behavior during extraction from ocean floor Mn nods
Han, <u>et al.</u> , 1974	Ammonia-ammonium leaching of deep-sea Mn nods
Hoover, 1972	Cu, Ni, Co from ocean Mn nods; mechanism and kinetics of chlorination
Hubred, 1973	Deep sea Mn nods; extractive metallurgy; sulfuric acid autoclave leach
Hubred, 1975	Deep-sea Mn nods: review of literature
Kaufman, R., 1972	Land-base needs for ocean Mn nod mining
Kruppa, 1973	Interocean '73, Düsseldorf
Mero, 1959	Mining and processing of Mn nods; ocean
Meyer-Galow, <u>et al.</u> , 1973a,b	Marine Mn nods; process engineering
Morgan, C., 1973	Processing of Mn nods; chem constraints
Neyland, 1968	Aluminothermic reduction of Mn ore; New Zealand
Perkins and Norvielli, 1962	Mn ores; bacterial leaching
Sorem and Foster, 1972a	Internal structure of Mn nods; implications in beneficiation
U.S. Dept. of Interior, Bureau of Mines, 1967	Summary of Bureau of Mines' research to extract Mn and other metals from undersea nods
Yousef, Arafa, and Boulos, 1971	Mn dioxide slimes; quartz flotation
Yousef, Boulos, and Ezz, 1969	Production of Fe-Mn from ferruginous Mn ores





S E C T I O N 2 5

ENVIRONMENTAL ASPECTS OF NODULE MINING, PROCESSING, AND UTILIZATION

This section lists articles dealing with the environmental and ecological aspects of manganese nodule mining, processing, and utilization.

ENVIRONMENTAL ASPECTS OF NODULE MINING, PROCESSING, AND UTILIZATION

- Amos, Garside, Haines, and  
Roels, 1972 Effects of mining effluent; ocean
- Amos, Garside, Gerard, et al.,  
1973a Mn nod mining; impact on seabed and  
water column
- Amos, Garside, Gerard, et al.,  
1973b Physical, chem, and biological  
oceanography of Mn nod province;  
mining impact; E Equat Pacific
- Anonymous, 1972b Environmental quality of seabed  
resources
- Anonymous, 1974g Ocean mining faces environmental  
hurdle
- Archer, 1970 Sub-sea minerals and environment
- Battelle Memorial Institute,  
1971 Environmental disturbances of concern  
to marine mining; selected annotated  
bibliography
- Cruickshank, 1972a Environmental and technological  
considerations in exploration and  
exploitation of Mn nods
- Devanney, et al., 1970 Economic aspects of solid waste  
disposal at sea
- Goldberg, 1971 Chem invasion of ocean by man
- Hood, 1971 Impingement of man on oceans
- Meiser and Müller, 1973a,b Mn nods; mineral resource; ocean
- Roels, 1972 Mn nod mining; environmental impact
- Voorhoeve, et al., 1973 Rare-earth manganites: catalysts with  
low ammonia yield; reduction of  
nitrogen oxides
- Voorhoeve, Remeika, et al.,  
1972 Mn and Co oxides; treatment of carbon  
monoxide in auto exhaust
- Welling, 1972 Deep-sea mining; environmental factors

Wu and Chu, 1972

Mn nods as catalysts for reduction  
of nitric oxide with ammonia

Zimmerly, 1967

Use of nods to remove sulfur from  
gases



## S E C T I O N 2 6

### LEGAL ASPECTS OF OCEAN-FLOOR MINING

This section lists articles dealing with legal questions regarding the exploitation of deep-sea manganese nodules and other seabed resources, i.e., Law of the Sea.

## LEGAL ASPECTS OF OCEAN-FLOOR MINING

Amann, 1973	Intl organization to explore and utilize mineral resources; ocean
Anonymous, 1974e	Institute surveys marine mining issues
Auburn, 1970a	Deep sea mining
Auburn, 1970b	Ocean mineral resources; law
Auburn, 1971a	Intl seabed area
Auburn, 1971b	Deep-sea mining
Auburn, 1972a	Intl law: ocean mining
Auburn, 1972b	Deep seabed hard mineral resources bill
Brooks, 1968	Deep sea Mn nod
Christy, 1968a	Alternative regimes for marine resources underlying high seas
Christy, 1968b	Economic criteria for rules governing exploitation of deep sea minerals
Christy, 1968c	Legal aspects of exploitation of offshore mineral deposits; mining in intl waters
Craven, 1972	Hawaii: seabed resources and law
Crutchfield and Adams, 1969	Marine resource development; legal and political arrangements
Dupuy, 1975	Prospects for economic and legal conquest of the seas
Ely, 1968	American policy options in development of undersea mineral resources
Flipse, <u>et al.</u> , 1973	Ocean mining law issue produces controversy
Henkin, 1973	Law of sea-mining
Kaufman, R. and Greenwald, 1972	Mn nod mining; technical progress and law

Koers, 1970	Debate on legal regime for exploration and exploitation of ocean resources; bibliography, 1960-1970
Meiser and Muller, 1973a,b	Mn nodds; mineral resource
Nordquist, 1972a	Law; exploitation of Mn nodds
Nordquist, 1972b	Law; deep sea mining
Ratiner, 1972	Public policy; US Senate Bill S 2801
Smith, W. J., 1972	Intl control of deep-sea mineral resources





ADDENDUM TO  
BIBLIOGRAPHY AND INDEX TO LITERATURE ON MANGANESE NODULES

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## INTRODUCTION

This addendum contains references that were recently selected for addition to the Manganese Project computerized bibliography at the Hawaii Institute of Geophysics, and is included here to facilitate access to the most recently acquired references in the field of manganese nodule research.

The addendum contains a total of 295 bibliographic entries. Exactly 50% of these references have a publication date of 1974 or 1975. (See Table 1, a chronological listing of the frequency of occurrence of publication dates.) Increased emphasis has been placed on the topics of water chemistry, radiochemistry, and marine metallogenic deposits. References on these subjects account for the bulk of the pre-1974 entries. The most recent literature survey for the purpose of selecting additional references was conducted in January 1976.

The index format is identical to that used in our previous work. Part II of this document should be consulted for information on its structure and the abbreviations used.

TABLE 1

FREQUENCY OF OCCURRENCE:  
BIBLIOGRAPHIC ENTRY PUBLICATION DATE

<u>Publication Date</u>	<u>Frequency of Occurrence</u>
1890. . . . .	1
1910. . . . .	1
1912. . . . .	1
1922. . . . .	2
1952. . . . .	3
1954. . . . .	1
1961. . . . .	1
1962. . . . .	2
1963. . . . .	9
1964. . . . .	12
1965. . . . .	13
1966. . . . .	12
1967. . . . .	8
1968. . . . .	15
1969. . . . .	19
1970. . . . .	23
1971. . . . .	3
1972. . . . .	2
1973. . . . .	19
1974. . . . .	61
1975. . . . .	87

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## INDEX ABBREVIATIONS

accum(s) = accumulation(s) or accumulating

assoc(s) = association(s) or associated

assoc/w = associated with

Atl = Atlantic Ocean

avg = average

Calif = California

chem = chemistry or chemical

distrib = distribution

DSDP = Deep Sea Drilling Project

DTA = differential thermal analysis

E = East

electrochem = electrochemistry or electrochemical

Equat = Equatorial

exped = expedition

Fe-Mn = ferromanganese

geochem = geochemistry or geochemical

HIG = Hawaii Institute of Geophysics

IDOE = International Decade of Ocean Exploration

Ind Oc = Indian Ocean

intl = international

Medit = Mediterranean Sea

micronod(s) = micronodules(s)

MORB = mid-ocean ridge basalt

N = North

nod(s) = nodule(s)

Pac = Pacific Ocean

petrol = petrology or petrologic

physiochem = physiochemistry or physiochemical

radiochem = radiochemistry or radiochemical

REE = rare-earth elements

S = South

sed = sediment or sedimentary

seds = sediments

SEM = scanning electron microscope or microscopy

spectrochem = spectrochemistry or spectrochemical

stratig = stratigraphy or stratigraphic

XRD = x-ray diffraction

W = West



Schafer, 1974	Sed deposition and lithogenesis; Mid-Atlantic Ridge mountain tops
<u>4b - PACIFIC OCEAN</u>	
Andrews, 1975	Equat NE Pac; geologic setting of Mn nod deposits
Bäcker, 1974	SW Pac Basin; <u>Tangaroa</u> cruise 22; Mn nods
Boström, Joensuu, <u>et al.</u> , 1974	E Pac Rise; new finds of exhalative deposits
Burnett, <u>et al.</u> , 1975	Galapagos spreading center, E Pac; geochem and age of Fe-Mn crust
Burns, R. G., <u>et al.</u> , 1975	NE Equat Pac; chem stratig mapping of Mn nods by electron microprobe; evidence of late stage Ni and Cu enrichments
Carsola and Dietz, 1952	NE Pac; submarine geology of two seamounts
Corliss and Dymond, 1975	Nazca Plate metalliferous seds; elemental distrib patterns in surface samples
Craig, J. D., 1975a, b	N Equat Pac; distrib of Fe-Mn nod deposits
Cronan, 1973a	NE Equat Pac; DSDP Leg 16; basal ferruginous seds cored
Cronan, 1973b	NE Equat Pac; DSDP Leg 16, Mn nods in sed s cored
Dugolinsky, 1975	NE Equat Pac; Cu and Ni enrichment in relation to major element composition in Mn nods
Dymond, Corliss, and Heath, 1975	Nazca Plate; DSDP Site 319; chem composition and metal accum rates of metalliferous sed s

Glasby, 1975c	SW Pac; Mn deposits
Glasby and Lawrence, 1974a	S Pac; Mn deposits; distrib
Glasby and Lawrence, 1974b	S Pac; Mn deposits; Mn content
Glasby and Lawrence, 1974c	S Pac; Mn deposits; Fe content
Glasby and Lawrence, 1974d	S Pac; Mn deposits; Cu content
Glasby and Lawrence, 1974e	S Pac; Mn deposits; Ni content
Glasby and Lawrence, 1974f	S Pac; Mn deposits; Co content
Glasby and Lawrence, 1974g	S Pac; metalliferous seds, submarine volcanism, submarine geothermal activity
Glasby and Singleton, 1975	SW Pac Basin; underwater photos of Mn nods
Glasby, Bäckér, and Meylan, 1975	SW Pac Basin; metal contents of Mn nods
Heath and Moberly, 1971	W Pac; DSDP Leg 7, noncalcareous pelagic seds
Heath, <u>et al.</u> , 1975	Nazca Plate; Bauer Deep and adjacent E Pac Rise; partitioning of transition metals amongst mineral phases in metalliferous seds
Kraemer and Schornick, 1974	S Pac; Fe-Mn deposits and seds; comparison of elemental accum rates
Lyle, <u>et al.</u> , 1975	Bauer Deep; factors controlling chem composition of Mn nods and crusts
Margolis, 1975	NE Equat Pac; microchem variations in Mn nods
Margolis, Bowser, <u>et al.</u> , 1975	NE Pac; <u>Moana Wave</u> cruise report Mn-74-02
McMurtry and Woollard, 1975	SW Pac, Bauer Deep; model for hydrothermal metallogenesis
Meylan, 1975	Pac; regional variations in Mn nod mineralogy
Meylan and Craig, 1975	NE Equat Pac; descriptive characterization of Mn nods



Meylan, <u>et al.</u> , 1974	S and SW of Rarotonga, Cook Islands; Mn nods
Natland, 1973	NW Pac; DSDP Site 183, Aleutian Abyssal Plain and DSDP Site 192, Meiji Guyot; basal Fe-Mn seds
Piper, D. Z., <u>et al.</u> , 1975	NE Pac; Dellwood Seamount; hydrothermal Fe-rich deposit
Senechal, <u>et al.</u> , 1975	Bauer Deep, Nazca Plate; isotopic, elemental and mineralogical distrib in metalliferous seds
Shterenberg and Shchurina, 1974	Pac; clay minerals in Fe-Mn concretions
Sung, <u>et al.</u> , 1975	NE Equat Pac; changing mineralogy and microchemistry in Mn nods
Williamson and Piper, 1973	NE Pac; single Fe-Mn nod; detailed sampling and mineralogical-chem analysis

4c - ATLANTIC OCEAN

Cronan, 1975	Atl; Mn nods and other Fe-Mn oxide deposits
Hekinian and Hoffert, 1975	Atl; rift valley near 36°50'N; rate of palagonitization and Mn coating on basaltic rocks
Hoffert, <u>et al.</u> , 1975	N Atl; authigenic attapulgite and phillipsite in Mn nod nuclei
McGregor and Rona, 1975	Mid-Atl Ridge; crest at 26°N
McKee, <u>et al.</u> , 1975	NW Atl; microstructure of Fe-Mn micronods
Murray, J. and Hjort, 1912	N Atl; <u>Michael Sars</u> ; samples
Scott, R. B., Malpas, <u>et al.</u> , 1975	Mid-Atl Ridge at 26°N; submarine hydro- thermal activity and seafloor spreading
Summerhayes and Willis, 1973	Agulhas Bank, S Atl; Mn encrustations
Summerhayes and Willis, 1975	Seafloor around S Africa; geochem of Mn deposits in relation to environment

Thompson, G., et al., 1975                      Mid-Atl Ridge; metalliferous deposits

4d - INDIAN OCEAN AND RED SEA

Amann, et al., 1973                              Red Sea and Gulf of Aden; marine  
metalliferous muds

Bignell, et al., 1974                              Red Sea; metalliferous seds;  
additional location

Cronan, Damiani, et al., 1974                      Gulf of Aden and W Ind Oc; seds

Degens and Ross, 1969                              Red Sea; hot brines and recent heavy  
metal deposits

Manheim, 1973                                      Red Sea; hot brine; metal deposits

Manheim, 1974                                      Red Sea; geochem

Summerhayes and Willis, 1975                      Seafloor around S Africa; geochem of  
Mn deposits in relation to environment

Tooms, 1970b                                      Red Sea; nature, origin, and economic  
worth of metal deposits

Warner and Gieskes, 1974                              Ind Oc; DSDP Site 245; Fe-rich basal  
sed

4e - ANTARCTIC OCEAN

Aumento and MacGillivray, 1975                      Antarctic Ocean; geochem of buried Miocene-  
Pleistocene Fe-Mn nod

Glasby and Lawrence, 1974a                              S Pac; Mn deposits; distrib

Glasby and Lawrence, 1974b                              S Pac; Mn deposits; Mn content

Glasby and Lawrence, 1974c                              S Pac; Mn deposits; Fe content

Glasby and Lawrence, 1974d                              S Pac; Mn deposits; Cu content

Glasby and Lawrence, 1974e                              S Pac; Mn deposits; Ni content

Glasby and Lawrence, 1974f                              S Pac; Mn deposits; Co content

Glasby and Lawrence, 1974g	S Pac; metalliferous seds, submarine volcanism, submarine geothermal activity
Kraemer and Schornick, 1974	S Pac; Fe-Mn deposits and seds; comparison of elemental accum rates
Margolis, 1974	Subantarctic; DSDP Leg 29; Mn deposits
Piper, D. J. W. and Brisco, 1975	Antarctica; DSDP Leg 28; deep-water continental-margin sedimentation; buried micro- and macro-nods

4f - ARCTIC OCEAN

None

4g - MEDITERRANEAN AND EUROPEAN SEAS

Andrussov, 1890	Black Sea; first Russian expedition; concretions around <u>Modiolus</u> shells
Babinets, <u>et al.</u> , 1973	Black Sea; deep-sea seds; hydro-geological and geochem properties
Rozanov, <u>et al.</u> , 1974	Black Sea; forms of Fe in surface layer of seds
Samoilov and Titov, 1922	Baltic Sea; concretions

4h - GULF OF MEXICO AND CARIBBEAN SEA

Chugunnyy and Kovalyukh, 1974	Caribbean Sea; radiocarbon investigations of Fe-Mn nodules; problems of water circulation in N Atl
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4i - WORLDWIDE

None

## 5 - FRESHWATER NODULES, CONCRETIONS, AND MANGANIFEROUS SEDIMENTS

- Chao and Anderson, 1975                      Colorado; stream seds of two drainage areas; scavenging of Ag by Mn and Fe oxides
- Coker and Nichol, 1975                      NW Ontario region of Canadian Shield; relation of lake sed geochem to mineralization
- Jenne and Wahlberg, 1965                      Oak Ridge, Tennessee; White Oak Creek sed; Mn and Fe oxide scavenging of cobalt-60
- Wakeham and Carpenter, 1974                      Fresh-water (and marine) Mn nods; electron spin resonance spectra

## 6 - SOIL NODULES AND CONCRETIONS

- Langmuir, et al., 1975                      Pennsylvania soil; geochem of Cu, Zn, Fe, Mn in soil moisture

## 7 - "FOSSIL" MANGANESE NODULES

- Aumento and MacGillivray, 1975                      Buried Miocene-Pleistocene Fe-Mn nods; geochem; Antarctic Ocean
- Cronan, 1973b                                      Mn nods in seds cored during DSDP Leg 16
- Piper, D. J. W. and Brisco, 1975                      Buried micro- and macro-nods; deep-water continental-margin sedimentation; DSDP Leg 28; Antarctica

## 8a - MANGANESE ORE DEPOSITS

- Coker and Nichol, 1975                      NW Ontario region of Canadian Shield; relation of lake sed geochem to mineralization
- Gavrilov, 1970                                      Exhalative sed Mn ore; role of diagenesis in formation

## 8b - MANGANESE IN ROCKS

- Kay, M., 1974 NE Newfoundland; Campbell sequence; manganiferous beds adjoining Dunnage melange
- Miall, 1974 Banks Island, NW Territories; Mn spherulites at intra-Cretaceous disconformity

## 9 - CHEMICAL COMPOSITION OF NODULES

- Andrussov, 1890 Concretions; Baltic Sea
- Aumento and MacGillivray, 1975 Buried Miocene-Pleistocene Fe-Mn nods; Antarctic Ocean; geochem
- Bäcker, 1974 Mn nods; SW Pac Basin; Tangaroa 22 cruise
- Banning, 1975 Marine Mn nods; Cu-Ni-Co assoc
- Burnett, et al., 1975 Fe-Mn crust; Galapagos spreading center, E Pac; geochem and age
- Burns, R. G., et al., 1975 Mn nods; NE Equat Pac; chem stratig mapping by electron microprobe; evidence of late stage Ni and Cu enrichments
- Cronan, 1975 Mn nods and other Fe-Mn oxide deposits; Atl Ocean
- Dugolinsky, 1975 Mn nods; NE Equat Pac; Cu and Ni enrichment in relation to major element composition
- Glasby, 1975d Mn nods; minor element enrichment relative to sea water and marine sed
- Glasby and Lawrence, 1974b Mn deposits; S Pac; Mn content
- Glasby and Lawrence, 1974c Mn deposits; S Pac; Fe content
- Glasby and Lawrence, 1974d Mn deposits; S Pac; Cu content
- Glasby and Lawrence, 1974e Mn deposits; S Pac; Ni content

Glasby and Lawrence, 1974f	Mn deposits; S Pac; Co content
Glasby, Bäckér, and Meylan, 1975	Mn nods; SW Pac Basin; metal contents
Isayeva, 1974	Variation of Mo/W ratio as function of sedimentation conditions
Lyle, <u>et al.</u> , 1975	Mn nods and crusts; Bauer Deep; factors controlling chem composition
Mahoney, <u>et al.</u> , 1975	Mn nods; particles contributing to growth; isotopic and chem analyses
Margolis, 1975	Mn nods; NE Equat Pac; microchem variations
Piper, D. Z., 1974b	Sed cycle; REE; summary
Pushkina, 1974	Profile crossing NE Pac Basin; sed niobium and tantalum
Samoilov and Titov, 1922	Concretions; Baltic Sea
Summerhayes and Willis, 1975	Mn deposits; seafloor around S Africa; geochem in relation to environment
Sung, <u>et al.</u> , 1975	Mn nods; NE Equat Pac; changing mineralogy and microchem
Williamson and Piper, 1973	Single Fe-Mn nod; NE Pac; detailed sampling and mineralogical-chem analysis
Yemel'yanov, 1974	Mn in deposits; Atl Ocean

#### 10 - CHEMICAL COMPOSITION OF SEDIMENTS ASSOCIATED WITH NODULES

Angino and Andrews, 1968	Trace element chem, heavy minerals, sed statistics; Weddell Sea seds
Antal, 1966	Diagenesis of Th isotopes; deep-sea seds
Babinets, <u>et al.</u> , 1973	Hydrogeological and geochem properties; deep-sea seds of Black Sea
Belova, 1970	Zn; Holocene Black Sea seds
Bennett and Manuel, 1968	Iodine abundances; deep-sea seds

Bernat and Goldberg, 1969	Th isotopes; marine environment
Bertine, <u>et al.</u> , 1970	U determinations using fission tracks; deep-sea seds and natural waters
Boström and Valdes, 1969	Arsenic; ocean floors
Cook, P. J., 1974	Major and trace element geochem; seds from DSDP Leg 27, Sites 259-263; E Ind Oc
Delevaux and Doe, 1974	U, Th, Pb contents and Pb isotopic composition; sed samples from Red Sea
Dvoretzkaya and Pushkina, 1974	Mineralogy and geochem; Ind Oc sed south of Sri Lanka (Ceylon)
Emelyanov, 1975	Ti; Atl Ocean seds
Frakes, 1975	Geochem; Ross Sea diamicts
Glagoleva, 1970	Zr; Recent Black Sea seds
Glasby, 1975d	Minor element enrichment in Mn nods relative to sea water and marine seds
Hirst, D. M., 1974	Geochem of seds; eleven Black Sea cores
Horowitz, 1970	Distrib of Pb, Ag, Sn, Ti, Zn; sed on active ocean ridges
Hurd, 1973	Interactions of biogenic opal, sed, seawater; central Equat Pac
Isayeva, 1974	Variation of Mo/W ratio as function of sedimentation conditions
Kalinenko and Morozov, 1974	Li, K, Rd, Cs; White Sea seds
Lal and Krishnaswami, 1973	Trace elements: sea water to sed
Lubchenko, 1970	Pb; Holocene Black Sea sed
Manheim, 1974	Red Sea geochem
Manheim and Siems, 1974	Chem analyses; Red Sea sed
Pimm, 1973	Trace element determinations compared with XRD results; brown clay; central Pac
Piper, D. Z., 1974b	REE in sed cycle; summary

Piper, D. Z., 1974c	REE cycle; marine environment; effects of formation of authigenic and biogenic phases
Pushkina, 1974	Sed niobium and tantalum; profile crossing NE Pac basin
Rozanov, <u>et al.</u> , 1974	Forms of Fe in surface layer; Black Sea seds
Sokolova and Pilipchuk, 1970	Selenium; Recent Black Sea seds
Sreekumaran, <u>et al.</u> , 1968	Concentration of Li, K, Rb, Cs; some American rivers and stream seds
Thompson, G., 1968	Analyses of B, Ga, Rb, K; two deep-sea sed cores; consideration of use as paleoenvironmental indicators
Turekian, 1964b	Geochem; Atl Ocean basin
Turekian, 1967	Material balance calculations; estimates of avg Pac deep sea clay accum rate
Volkov, Sokolov, <u>et al.</u> , 1974	Rare and trace elements; seds of NW Pac
Windom, 1970	Atmospherically transported trace metals; contribution to S Pac seds
Yemel'yanov, 1974	Mn in deposits; Atl Ocean

#### 11 - CHEMICAL ELEMENTS IN AQUEOUS SOLUTIONS

Alexander and Corcoran, 1967	Distrib of Cu; tropical seawater
Andersen and Hume, 1968	Sr, Ba content; sea water
Angino and Billings, 1966	Trace element chem, heavy minerals, sed statistics; Weddell Sea seds
Anonymous, 1964	Chem and the oceans
Barnes, I. and Hem, 1973	Chem of subsurface waters
Bender and Gagner, 1975	Dissolved Cu, Ni, Cd in sea water; measurements of concentration
Bernat and Goldberg, 1969	Th isotopes; marine environment



Berner, 1964	Dissolved sulfate distrib in Recent seds; idealized model
Berner, 1975	Dissolved species in interstitial waters of compacting seds; diagenetic models
Berrang and Grill, 1974	Effect of Mn oxide scavenging on Mo; Saanich Inlet, British Columbia
Bertine, <u>et al.</u> , 1970	Uranium determinations using fission tracks; deep sea seds and natural waters
Bischoff and Ku, 1970	Pore fluids of Recent marine seds: oxidizing seds of 20°N; continental rise to Mid-Atlantic Ridge
Bowser, <u>et al.</u> , 1975	Pore fluid chem: nutrients and dissolved oxygen; Mn nod-rich seds; E Equat Pac
Brewer, <u>et al.</u> , 1965	Chem composition of hot salty water; bottom of Red Sea
Broecker, 1966	Radioisotopes; rate of mixing across main thermocline of ocean
Brooks, R. R., <u>et al.</u> , 1968	Trace elements; interstitial waters of marine seds
Callender, <u>et al.</u> , 1975	Pore fluid chem; Mn nod-rich seds; E Equat Pac
Carpenter, J. H., 1967	Cerium in coastal waters; concentration and state
Carr, R. A., <u>et al.</u> , 1974	Anomalous mercury; near-bottom water; mid- Atlantic rift valley
Chao and Anderson, 1975	Scavenging of Ag by Mn and Fe oxides; stream seds; two drainage areas of Colorado
Chester and Stoner, 1974	Zn, Ni, Mn, Cd, Cu, Fe; distrib in some surface waters from world ocean
Chow, 1968	Pb isotopes; Red Sea region
Chow and Snyder, 1969	Indium contents; sea water

Craig, H., 1966	Isotopic composition and origin; Red Sea and Salton Sea geothermal brines
Curl, <u>et al.</u> , 1965	Uptake of Cr(III) by particles in sea water
Degens and Ross, 1969	Hot brine and Recent heavy metal deposits; Red Sea
Doe, <u>et al.</u> , 1966	Source of Pb and Sr in deep geothermal brines; Salton Sea geothermal area
Duinker, <u>et al.</u> , 1974	Behavior of Cu, Zn, Fe, Mn; evidence for mobilization processes; Dutch Wadden Sea
Ellis, A. J. and Mahon, 1964	Natural hydrothermal systems; experimental hot-water/rock interactions
Fabricand, Imbimbo, <u>et al.</u> , 1966	Li, K, Rb, Sr in ocean water; atomic absorption analyses
Fabricand, Sawyer, <u>et al.</u> , 1962	Trace metal concentrations in ocean; atomic absorption spectroscopy
Fanning and Schink, 1969	Dissolved silica; interaction with marine seds
Forster and Zeitlin, 1966a	Co in sea water; determination by modified nitroso-R method
Forster and Zeitlin, 1966b	Ni in sea water; determination by modified dimethylglyoxin method
Foster, P. and Hunt, 1975	Geochem of surface seds; acid stream estuary
Friedman, <u>et al.</u> , 1968	Interstitial waters from continental shelf seds; chem changes
Garrels, 1965	Silica: role in buffering of natural waters
Garrels and Thompson, 1962	Sea water at 25°C and one atmosphere total pressure; chem model
Glasby, 1975d	Minor element enrichment in Mn nods relative to sea water and marine seds
Hanor and Chan, 1975	Behavior of barium during mixing of Mississippi River and Gulf of Mexico waters

Healy, M. L. and Kieffer, 1973	Nature of Mn; Saanich Inlet, an intermittently anoxic fjord
Helgeson and Mackenzie, 1970	Silicate-sea water equilibria; ocean systems
Hem, 1965	Reduction and complexing of Mn by gallic acids
Hurd, 1973	Interactions of biogenic opal, sed, and sea water; central Equat Pac
Ingols and Wilroy, 1963	Mechanism of Mn solution; lake waters
Kaufman, A., 1969	Th <sup>232</sup> concentration; surface ocean water
Kester, <u>et al.</u> , 1975	Transition metal absorption from sea water
Kido and Nishimura, 1975	Silica in sea; forms and dissolution rate
Klinkhammer, <u>et al.</u> , 1975	Mn in sea water; marine Mn balance
Ku, Li, <u>et al.</u> , 1970	Radium; Indian-Antarctic Ocean south of Australia
Lal and Krishnaswami, 1973	Trace metals: sea water to sed
Langmuir, <u>et al.</u> , 1975	Geochem of Cu, Zn, Fe, Mn in soil moisture; Pennsylvania soil
Long and Angino, 1975	Zn, Cu, Cd, Pb; speciation in river, estuarine, marine environments
Mackenzie, F. T. and Garrels, 1965	Silicates: reactivity with sea water
Mackenzie, F. T. and Garrels, 1966	Chem mass balance between rivers and oceans
Manheim, 1970	Diffusion of ions in unconsolidated sed
Manheim, 1974	Red Sea geochem
Millero, 1974	Physical chem of seawater
Moore, W. S., 1969b	Ra <sup>228</sup> and Th <sup>228</sup> ; measurement in sea water
Morey, <u>et al.</u> , 1965	Amorphous silica; solubility at 25°C

Morris, 1975	Dissolved Mo, V; NE Atl Ocean
Mottl, <u>et al.</u> , 1975	Trace element content; Reykjanes and Svartsengi thermal brines, Iceland
Murray, J. W., 1975a, b	Interaction of cobalt with hydrous Mn dioxide
O'Connor, T. P., 1974	Adsorption of Cu, Co from aqueous solution onto illite and other substrates
Orlova, 1974	Suspended and dissolved forms of cobalt; content of Fe, Mn, Cu; correlation in waters of North and Norwegian Seas
Picciotto, 1961	Geochem of radioactive elements in ocean; chronology of deep-sea sed
Pilipchuk, 1974	Arsenic distrib; Black Sea water
Presley, <u>et al.</u> , 1974	Interstitial water chem; DSDP Leg 23; Red Sea
Pytkowicz, 1975	Water composition and element cycles; trends in marine chem and geochem
Ryabinin, <u>et al.</u> , 1974	Au in ocean waters
Sackett and Cook, 1969	Uranium geochem; Gulf of Mexico
Sayles and Manheim, 1975	Interstitial solutions and diagenesis; deeply buried marine sed; DSDP results
Scadden, 1969	Rhenium; concentration in Pac Ocean surface waters
Sclater, <u>et al.</u> , 1975	Ni; marine geochem
Siever, <u>et al.</u> , 1965	Composition of interstitial waters; modern sed
Siniukov, 1964	Chem of sea water; influence of volcanic eruptions
Slowey and Jeffrey, 1967	Evidence for organic complexed Cu in sea water
Spencer and Sachs, 1970	Suspended matter; aspects of distrib, chem, mineralogy; Gulf of Maine
Sreekumaran, <u>et al.</u> , 1968	Li, K, Rb, Cs; concentration in some American rivers and marine sed

Szabo, <u>et al.</u> , 1967	Ra and radiocarbon in Caribbean waters
Tatsumoto and Patterson, 1963	Common Pb; concentration in sea water
Turekian, 1964b	Geochem; Atl Ocean basin
Veeh, 1967	Uranium; deposition from ocean
Veeh, 1968	$^{234}\text{U} / ^{238}\text{U}$ ; E Pac sector of Antarctic Ocean and Red Sea
Wolgemuth and Broecker, 1970	Ba in sea water

12 - DISTRIBUTION, MINERALOGY, AND PHYSICAL PROPERTIES OF SEDIMENTS  
ASSOCIATED WITH MANGANESE DEPOSITS

Angino and Andrews, 1968	Trace element chem, heavy minerals, sed statistics; Weddell Sea sed
Arrhenius, 1952	Sed cores; E Pac
Biscaye, 1964	Mineralogy and sedimentation; deep-sea sed fine fraction; Atl Ocean and adjacent seas and oceans
Bonatti, 1963	Zeolites; Pac pelagic sed
Caspari, 1910	Oceanic clays; composition and character
Cronan, Damiani, <u>et al.</u> , 1974	Seds; Gulf of Aden and W Ind Oc
Dvoretzkaya and Pushkina, 1974	Mineralogy and geochem; Ind Oc sed; south of Sri Lanka (Ceylon)
Fuller, <u>et al.</u> , 1966	Sed above basalt; magnetic and petrologic studies; experimental Mohole core EM7
Goldberg and Griffin, 1964	Sedimentation rates and mineralogy; S Atl
Goldberg and Griffin, 1970	Seds; N Ind Oc
Griffin and Goldberg, 1963	Clay mineral distribs; Pac Ocean
Hathaway and Sachs, 1965	Sepiolite, clinoptilolite; Mid-Atlantic Ridge
Hay, 1966	Zeolites and zeolitic reactions in sed rocks

Heath, 1969	Mineralogy; Cenozoic deep-sea seds; Equat Pac Ocean
Heath and Moberly, 1971	Noncalcareous pelagic seds; DSDP Leg 7; W Pac
Nafe and Drake, 1963	Marine seds; physical properties
Ninkovich, <u>et al.</u> , 1964	S Sandwich tephra in deep-sea seds
Rex, <u>et al.</u> , 1969	Quartz in soils of Hawaiian Islands, Pac pelagic seds; eolian origin
Schafer, 1974	Sed deposition and lithogenesis; Mid- Atlantic Ridge mountain tops near 45°N
Siever and Kastner, 1967	Mid-Atlantic Ridge seds; mineralogy and petrology
Windom, 1970	Contrib of atmospherically transported trace metals; S Pac seds

### 13 - PETROLOGY AND CHEMISTRY OF ROCKS ASSOCIATED WITH MANGANESE DEPOSITS

Bougalt, 1975	Distrib of first series transition metals in rocks; DSDP Leg 22; NE Ind Oc
Fein and Palmiter, 1975	Microchem of basaltic pillow lavas; Nazca Plate
Kay, R., <u>et al.</u> , 1970	Chem characteristics and origin; oceanic ridge volcanic rocks
Noble and Naughton, 1968	Deep-ocean basalts: inert gas content and uncertainties in age dating
Philpotts, <u>et al.</u> , 1969	Submarine basalts; K, Rb, Sr, Ba, REE, H <sub>2</sub> O, CO <sub>2</sub> data bearing on their altera- tion, modification by plagioclase, possible source materials
Tatsumoto, <u>et al.</u> , 1965	Oceanic tholeiitic basalt; K, Rb, Sr, Th, U, and Sr <sup>87</sup> to Sr <sup>86</sup> ratio

#### 14a - MINERALOGY OF MANGANESE NODULES

- |                                 |   |
|---------------------------------|---|
| Cronan, 1975                    | Mn nods and other Fe-Mn deposits;<br>Atl Ocean  |
| Fewkes, 1975                    | Correlation between morphology and<br>mineralogy of marine Mn nods; possible<br>economic significance |
| Hoffert, <u>et al.</u> , 1975   | Authigenic attapulgite and phillipsite<br>in Mn nod nuclei; N Atl Ocean                               |
| Meylan, 1975                    | Regional variations in Mn nod<br>mineralogy; Pac Ocean  |
| Shterenberg and Shchurina, 1974 | Clay minerals in Fe-Mn concretions; Pac<br>Ocean  |
| Sung, <u>et al.</u> , 1975      | Changing mineralogy and microchem in Mn<br>nods; NE Equat Pac   |
| Williamson and Piper, 1973      | Detailed sampling and mineralogical-chem<br>analysis; single Fe-Mn nod; NE Pac                        |

#### 14b - MANGANESE MINERALS

None

#### 15 - GEOCHEMISTRY AND STRUCTURE OF FERROMANGANESE OXIDES AND HYDROXIDES

- |                          |  |
|--------------------------|--|
| Berner, 1969             | Goethite stability; origin of red beds   |
| Cronan, 1975             | Mn nods and other Fe-Mn oxide deposits;<br>Atl Ocean                                   |
| Jenne and Wahlberg, 1965 | Mn and Fe oxide scavenging of cobalt-60;<br>White Oak Creek sed (Oak Ridge, Tennessee) |
| Langmuir, 1970           | Reaction hematite + water = goethite;<br>effect of particle size                       |
| Murray, J. W., 1975a, b  | Interaction of Co with hydrous Mn dioxide  |
| Sillen and Martell, 1964 | Metal-ion complexes; stability constants   |

Wakeham and Carpenter, 1974

Marine and freshwater Mn nodds;  
electron spin resonance spectra

16 - GEOCHEMICAL PROCESSES AND ENVIRONMENTAL CONTROLS RELEVANT TO  
Mn-NODULE FORMATION

Antal, 1966

Diagenesis of Th isotopes in deep-sea  
seds

Bacon, M. P., et al., 1975

Deep-sea scavenging of Pb-210, Po-210

Berner, 1975

Diagenetic models of dissolved species;  
interstitial waters of compacting seds

Berrang and Grill, 1974

Effect of Mn oxide scavenging on Mo;  
Saanich Inlet, British Columbia

Burns, R. G. and Fyfe, 1967b

Trace element distrib rules and their  
significance

Chao and Anderson, 1975

Scavenging of Ag by Mn and Fe oxides in  
stream seds; two drainage areas of  
Colorado

Curl, et al., 1965

Uptake of Cr(III) by particles of sea  
water

Duinker, et al., 1974

Behavior of Cu, Zn, Fe, Mn and evidence  
for mobilization processes

Ellis, A. J. and Mahon, 1964

Natural hydrothermal systems; experimental  
hot-water/rock interactions

Fanning and Schink, 1969

Interaction of marine seds with dissolved  
silica

Foster, P. and Hunt, 1975

Geochem of surface seds; acid stream  
estuary

Garrels, 1965

Buffering of nature waters; role of silica

Gavrilov, 1970

Formation of exhalative sed Mn ore; role  
of diagenesis

Gruner, 1922

Origin of sed Fe formations; Biwabik  
Formation of Mesabi Range

Hay, 1966

Zeolites and zeolitic reactions; sed  
rocks



Heath, <u>et al.</u> , 1975	Partitioning of transition metals amongst mineral phases in metalliferous sed; Bauer Deep and adjacent E Pac Rise
Hekinian and Hoffert, 1975	Rate of palagonitization and Mn coating on basaltic rocks; rift valley, Atl Ocean near 36°50'N
Hem, 1965	Reduction and complexing of Mn by gallic acids
Ingols and Wilroy, 1963	Mechanism of Mn solution; lake waters
Isayeva, 1974	Variation of Mo/W ratio as function of sedimentation conditions
Kester, <u>et al.</u> , 1975	Transition metal adsorption from marine waters
Langmuir, 1970	Reaction hematite + water = goethite; effect of particle size
Mackenzie, F. T. and Garrels, 1965	Reactivity of silicates with sea water
Mackenzie, F. T. and Garrels, 1965	Chem mass balance between rivers and oceans
Manheim, 1970	Diffusion of ions in unconsolidated sed
Miall, 1974	Mn spherulites at intra-Cretaceous disconformity; Banks Island, NW Territories
Murray, J. W., 1975a, b	Interaction of Co with hydrous Mn dioxide
O'Connor, T. P., 1974	Adsorption of Cu and Co from aqueous solution onto illite and other substrates
Piper, D. Z., 1974c	Cycle of REE in marine environment; effects of formation of authigenic and biogenic phases
Pytkowicz, 1975	Water composition and element cycles; trends in marine chem and geochem
Sayles and Manheim, 1975	Interstitial solutions and diagenesis in deeply buried marine sed; DSDP results
Thompson, G., 1973	Low temperature interaction of sea water and oceanic igneous rocks; geochem study

17 - FORMATION AND ORIGIN OF MANGANESE ACCUMULATIONS (GENERAL)

- Craig, J. D., 1975a, b                      Distrib of Fe-Mn nod deposits; N Equat  
Pac
- Gavrilov, 1970                              Formation of exhalative sed Mn ores;  
role of diagenesis

18a - MARINE METALLOGENIC DEPOSITS AND FERROMANGANOAN SEDIMENTS

- Amann, et al., 1973                      Metalliferous muds of marine environment;  
Red Sea and Gulf of Aden
- Bignell, et al., 1974                      Metalliferous seds; additional location  
in Red Sea
- Bonatti, 1974                              Volcanogenic and hydrothermal seds; deep  
ocean basins
- Boström, Joensuu, et al., 1974              Exhalative deposits; new finds on E Pac  
Rise
- Corliss and Dymond, 1975                      Nazca Plate metalliferous seds; elemental  
distrib patterns in surface samples
- Cronan, 1973a                              Basal ferruginous seds cored during  
Leg 16, DSDP
- Degens and Ross, 1969                      Hot brines and Recent heavy metal  
deposits; Red Sea
- Dymond, Corliss, and Heath,  
1975    Chem composition and metal accum rates  
of metalliferous seds; DSDP Site 319,  
Nazca Plate
- Glasby and Lawrence, 1974g                      Metalliferous seds, submarine volcanism,  
submarine geothermal activity; S Pac  
Ocean
- Gruner, 1922                              Origin of sed Fe formations; Biwabik  
Formation of Mesabi Range
- Heath, et al., 1975                      Partitioning of transition metals amongst  
mineral phases in metalliferous seds;  
Bauer Deep and adjacent E Pac Rise;  
Nazca Plate

Manheim, 1973	Hot brine, metal deposits; Red Sea
Manheim, 1974	Red Sea geochem
Manheim and Siems, 1974	Chem analyses of Red Sea seds
McMurtry and Woollard, 1975	Model for hydrothermal metallogenesis; Bauer Deep, SE Pac
Natland, 1973	Basal Fe-Mn seds; DSDP Site 183, Aleutian Abyssal Plain and Site 192, Meiji Guyot; DSDP Leg 16; NW Pac
Piper, D. Z., <u>et al.</u> , 1975	Hydrothermal Fe-rich deposit; upper flank of Dellwood Seamount; NE Pac
Schott, 1974	Submarine mineral deposits in oceans
Scott, R. B., Malpas, <u>et al.</u> , 1975	Submarine hydrothermal activity and seafloor spreading; 26°N, MAR
Senechal, <u>et al.</u> , 1975	Isotopic, elemental, mineralogical distrib in size fractions; Bauer Deep sample; Nazca Plate
Thompson, G., <u>et al.</u> , 1975	Metalliferous deposits; Mid-Atlantic Ridge
Tooms, 1970b	Red Sea metal deposits; nature, origin and economic worth
Warner and Gieskes, 1974	Fe-rich basal seds; DSDP Site 245, Ind Oc

18b - ASSOCIATION OF Mn-NODULES WITH SUBMARINE VOLCANICS; VOLCANIC ORIGIN  
OF Mn-NODULES AND NODULE METALS

Arrhenius, 1952	Sed cores; E Pac
Brewer, <u>et al.</u> , 1965	Chem composition of hot salty water; bottom of Red Sea
Carr, R. A., <u>et al.</u> , 1974	Anomalous Hg in near-bottom water; mid- Atl rift valley
Craig, H., 1966	Isotopic composition and origin; Red Sea and Salton Sea geothermal brines
Degens and Ross, 1969	Hot brines and Recent heavy metal deposits

- Doe, et al., 1966 Source of Pb and Sr in deep geothermal brines underlying Salton Sea geothermal area
- Glasby and Lawrence, 1974g Metalliferous seds, submarine volcanism, submarine geothermal activity; S Pac Ocean
- Hekinian and Hoffert, 1975 Rate of palagonitization and Mn coating on basaltic rocks from rift valley; Atl Ocean near 36°50'N
- Horowitz, 1970 Pb, Ag, Sn, Ti, Zn; distrib in seds on active oceanic ridges
- Huang, et al., 1975 Sub-Antarctic volcanism, S Pac; Late Pliocene and Pleistocene; atmospherically transported volcanic glass in deep-sea seds
- Manheim, 1973 Hot brine and metal deposits; Red Sea
- Manheim, 1974 Red Sea geochem
- McBirney, 1963 Submarine volcanism; factors governing nature
- Mottl, et al., 1975 Trace element content; Reykjanes and Svartsengi thermal brines; Iceland
- Ninkovich, et al., 1964 S Sandwich tephra in deep-sea seds
- Schafer, 1974 Igneous rock fragments of explosive origin; sed deposition and lithogenesis; Mid-Atlantic Ridge mountain tops near 45°N
- Siniukov, 1964 Chem of sea water; influence of volcanic eruptions
- Thompson, G., 1973 Low temperature interaction of sea water and oceanic igneous rocks; geochem study

#### 19a - BIOGEOCHEMISTRY OF MANGANESE AND OTHER ELEMENTS

- Boström, Joensuu, and Brohm, 1974 Plankton: chem composition and significance as source of pelagic seds
- Boström, Moore, and Joensuu, 1975 Plankton: chem composition and significance as sed source

- Piper, D. Z., 1974c                      Cycle of REE in marine environment;  
effects of formation of authigenic  
and biogenic phases
- Pyle and Tieh, 1970                      Sr, V, Zn in pteropod shells
- Slowey and Jeffrey, 1967                Evidence for organic complexed Cu in  
sea water
- Sorokin, 1970                              Abundance and production of bacteria  
in water and bottom sed; central Pac

19b - BIOLOGICAL ORIGIN OF NODULES; ASSOCIATION OF ORGANISMS AND Mn-NODULES

- Dugolinksy, et al., 1975                Influence of benthic biota on growth of  
deep sea Mn nods
- LaRock and Ehrlich, 1975                Bacterial microcolonies on surface of  
Fe-Mn nods; Blake Plateau; SEM  
observations
- Sorokin, 1970                              Abundance and production of bacteria in  
water and bottom sed; central Pac

20 - INTERNAL STRUCTURE AND EXTERNAL MORPHOLOGY OF NODULES

- Bäcker, 1974                              Mn nods; Tangaroa 22 cruise report; SW  
Pac Basin
- Craig, J. D., 1975a                        Distrib of Fe-Mn nod deposits; N Equat  
Pac
- Fewkes, 1975                              Correlation between morphology and  
mineralogy of marine Mn nods; possible  
economic significance
- McKee, et al., 1975                        Microstructure of Fe-Mn micronods; NW  
Atl Ocean
- Meylan and Craig, 1975                    Descriptive characterization of Mn nods;  
NE Equat Pac Ocean
- Sorem, 1975                                Rest position relationships of Mn nods  
and subjacent sed as key to nod origin

21 - RADIOGEOCHEMISTRY OF NODULES; RATES OF NODULE GROWTH

- Antal, 1966 Th isotopes; diagenesis in deep-sea seds
- Bacon, M. P., et al., 1975 Pb-210, Po-210; deep-sea scavenging
- Bernat and Goldberg, 1969 Th isotopes in marine environment
- Bertine, et al., 1970 U determinations using fission tracks; deep-sea seds and natural waters
- Brown, J. S., 1965 Oceanic Pb isotopes and ore genesis
- Burnett, et al., 1975 Geochem and age determinations of Fe-Mn crust; Galapagos spreading center, E Pac
- Centre des Faibles Radioactivités, 1975 Study of nods from principal exploration zones
- Chow, 1968 Pb isotopes in Red Sea region
- Chugunnyy and Kovalyukh, 1974 Radiocarbon investigations of Fe-Mn nods from Caribbean Sea; problems of N Atl water circulation
- Delevaux and Doe, 1974 U, Th, Pb contents and Pb isotopic composition; Red Sea sed samples
- Doe, et al., 1966 Source of Pb and Sr in deep geothermal brines underlying Salton Sea geothermal area
- Dymond, 1966 K-Ar geochronology; deep-sea seds
- Dymond, 1969 Age determinations of deep-sea seds; comparison of three methods
- Dymond, 1970 Excess argon in submarine basalt pillows
- Fisher, D. E., 1969 Fission track dating; deep sea glasses
- Funkhouser, et al., 1968 Excess argon in deep-sea rocks
- Goldberg, 1968 Ionium/thorium geochronologies
- Heye, 1970 System for detection of Io, Th, Pa; deep sea core dating
- Huang, et al., 1975 Micronod accum rate; atmospherically transported volcanic glass; Late Pliocene-Pleistocene sub-Antarctic volcanism; S Pac

Hurley, <u>et al.</u> , 1963	K-Ar age values; pelagic seds; N Atl
Jenne and Wahlberg, 1965	Mn and Fe oxide scavenging of Co-60; White Oak Creek sed (Oak Ridge, Tennessee)
Kaufman, A., 1969	<sup>232</sup> Th concentration of surface ocean water
Kharkar, <u>et al.</u> , 1969	<sup>32</sup> Si and U decay series determinations; comparison of sedimentation rates; siliceous Antarctic cores
Koczy, 1963	Age determinations by natural radio- activity; seds
Kraemer and Schornick, 1974	Fe-Mn deposits and seds; comparison of elemental accum rates; S Pac Ocean
Ku, <u>et al.</u> , 1975	Evaluation of dating nodds by U-series isotopes
Ku, Li, <u>et al.</u> , 1970	Ra; Indian-Antarctic Ocean, south of Australia
Moore, W. S., 1969b	<sup>228</sup> Ra, <sup>228</sup> Th; measurement in sea water
Morgenstein and Riley, 1975	Hydration rind dating of basaltic glass; archaeological chronologies
Noble and Naughton, 1968	Inert gas content and uncertainties in age dating; deep-ocean basalts
Osmond and Pollard, 1968	Sedimentation rate; deep sea cores; determination by gamma-ray spectrometry
Picciotto, 1961	Geochem of radioactive elements in ocean; deep-sea sed chronology
Picciotto and Wilgain, 1954	Th determination in deep-sea seds
Sackett and Cook, 1969	U geochem; Gulf of Mexico
Sarma, 1964	Io, Pa methods; dating marine seds
Scott, M. R., 1968	Th, U concentrations and isotope ratios; river seds
Sinclair, 1965	Oceanic Pb isotopes and ore genesis; discussion

Szabo, <u>et al.</u> , 1967	Ra and radiocarbon; Caribbean waters
Tatsumoto and Patterson, 1963	Common Pb; concentration in sea water
Tatsumoto, <u>et al.</u> , 1965	K, Rb, Sr, Th, U and $Sr^{87}/Sr^{86}$ ratio; oceanic tholeiitic basalt
Veeh, 1967	Deposition of U from ocean
Veeh, 1968	$U^{234}/U^{238}$ ; E Pac sector of Antarctic Ocean and Red Sea

## 22 - INSTRUMENTAL AND ANALYTICAL TECHNIQUES FOR STUDYING NODULES

Angino and Billings, 1966	Atomic absorption spectrometry; Li content of sea water
Bertine, <u>et al.</u> , 1970	Uranium determinations using fission tracks; deep-sea seds and natural waters
Burns, R. G., <u>et al.</u> , 1975	Electron microprobe; chem stratig mapping of Mn nods; evidence of late stage enrichments; NE Equat Pac
Fabricand, Imbimbo, <u>et al.</u> , 1966	Atomic absorption analyses; Li, Mg, K, Rb, Sr in ocean waters
Fabricand, Sawyer, <u>et al.</u> , 1962	Atomic absorption spectroscopy; trace metal concentrations in ocean
Fisher, D. E., 1969	Fission track dating; deep sea glasses
Forster and Zeitlin, 1966a	Modified nitroso-R method; determination of Co in sea water
Forster and Zeitlin, 1966b	Modified dimethylglyoxin method; determination of Ni in sea water
Heye, 1970	System for detection of Io, Th, Pa to date deep sea cores
LaRock and Ehrlich, 1975	SEM observations of bacterial micro-colonies on surface of Fe-Mn nods; Blake Plateau
Mahoney, <u>et al.</u> , 1975	Isotopic and chem analyses; particles contributing to Mn nod growth



Osmond and Pollard, 1968                      Gamma-ray spectrometry; sedimentation  
rate determination in deep sea cores

23 - COSMIC SPHERULES IN NODULES AND ASSOCIATED SEDIMENTS

Fredriksson and Martin, 1963                      Origin of black spherules; Pac islands,  
deep-sea seds, Antarctic ice

Merrihue, 1964                                      Rare gas evidence for cosmic dust;  
modern Pac red clay

Mutch and Garrison, 1965                      Extraterrestrial spherule abundances;  
determination of sedimentation rates

24a - ECONOMIC POTENTIAL OF MANGANESE NODULES

Anonymous, 1969c                                      Ocean firm launches \$100-\$200 million  
mining venture

Anonymous, 1970g                                      Going after riches

Anonymous, 1974h                                      Mineral resources of deep seabed

Anonymous, 1975b                                      Study assesses value of seabed nodules

Anonymous, 1975e                                      Inco joins seabed mining venture

Anonymous, 1975j                                      Mining; outer continental shelf and  
deep sea

Cruickshank, 1974a                                      Mineral resources potential of  
continental margins

Flipse, 1975    Ocean mining; promises and problems

Glasby, 1975a    Marine mining in New Zealand: prospects  
for development

McKelvey, 1968    Mineral potential of submerged parts of  
US

Mero, 1952    Manganese

Mero, 1964b    Mineral resources of the sea

Schott, 1974    Submarine mineral deposits in ocean

Tooms, 1970b    Metal deposits in Red Sea; nature,  
origin, economic worth

## 24b - NODULE EXPLORATION AND MINING

Amann, 1975	Definition of ocean mining site
Anonymous, 1971i	Ocean mining comes of age, part 2
Anonymous, 1975i	Mn nod mining venture a CIA cover
Anonymous, 1975j	Mining; outer continental shelf and deep sea
Boes and Bade, 1971	Dual-pipe transport system for deep ocean ore mining
Flipse, 1975	Ocean mining; promises and problems
Garland and Hagerty, 1972	Mining systems; environmental planning considerations for deep ocean mining
Hirst, T. J. and Richards, 1975	Analysis of deep-sea nod mining--seafloor interaction
Noakes, <u>et al.</u> , 1975	Surveillance system for subsea survey and mineral exploration
Pearson, 1975	Ocean floor mining
Siapno and Zahn, 1974	Navigation requirements for nod exploration and mining
Vigil, <u>et al.</u> , 1975	Deep-sea survey system
Wakefield, 1969	Mining hard minerals three miles under water
Wing, 1974	Project development plan deep ocean mining

## 24c - METALLURGICAL PROCESSING OF NODULES

Morgan, C. L. and Moore, 1974	Fe-Mn nods: processing guidelines for marine mine
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## 25 - ENVIRONMENTAL ASPECTS OF NODULE MINING, PROCESSING, AND UTILIZATION

- Amos, Daubin, et al., 1974      Environmental impact of Mn-nod mining; study of baseline conditions in Mn nod province
- Amos, Daubin, et al., 1975      Environmental baseline conditions in Mn-nod province
- Cross, 1975      Marine environmental engineering handbook
- Cruickshank, 1974b      Environmental statement for US involvement in law of the sea negotiations governing mining of deep seabed hard mineral resources seaward of limits of national jurisdiction
- Garland and Hagerty, 1972      Environmental planning considerations for deep ocean mining
- Gerard, 1975      Environmental hazards of deep-sea mining
- Hirst, T. J. and Richards, 1975      Analysis of deep-sea nod mining--seafloor interaction
- Roels, 1974a      Will nod mining disturb marine environment?
- Roels, 1974b      Suggested procedure to insure safe development of deep-sea mining
- Roels, Amos, et al., 1972, 1973      Environmental impact of deep-sea mining

## 26 - LEGAL ASPECTS OF OCEAN-FLOOR MINING

- Alexander, L. M., 1974      Law of the sea at end of decade: a prediction
- Anderson, E. V., 1975      Ocean mining firms look for green light
- Anonymous, 1975c      Leasing system may hinder ocean mining
- Anonymous, 1975d      Ocean mining: UN or US
- Anonymous, 1975f      Seabed mining authority: a lingering issue

Anonymous, 1975g	US industry, government up in arms over sea law meeting results
Anonymous, 1975h	White House support grows for ocean mining legislation prior to final Law of Sea treaty
Cruickshank, 1974b	Environmental statement for US involvement in law of the sea negotiations governing mining of deep seabed hard mineral resources seaward of limits of national jurisdiction
Gamble and Pontecorvo, 1973	Law of the sea; emerging regime of oceans
Glasby, 1975b	Mn nods and UN
Laylin, 1973	Practical measures to advance orderly deep sea mining
Nordquist, 1973	Outline of marine resource issues in law of the sea negotiations
Shapley, 1974	War of nods