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IAGOD COMMISSION ON MANGANESE IGCP PROJECT No. 111: GENESIS OF MANGANESE ORE DEPOSITS NOTES and NEWS

Brief Summary of Papers Presented at Technical Sessions of the Commission on Manganese, Snowbird, August, 1978

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The Commission was alloted time for two technical sessions. During the first, held Thursday, August 17, the first paper was presented by DR. ROGER KEY, of Botswana. He reported on *"The Stratabound Manganese Deposit of the Palapye Group, Botswana"*. The manganiferous beds are clastic sedimentary rocks which have a maximum thickness of ten metres and have been traced almost continuously along the strike for 48 kilometers. At depth the Mn content is low, but near-surface enrichment has produced a zone as deep as 1.5 metres which in places contains as much as 70.2 percent MnO_2. Diamond drilling suggests that enrichment in Mn has only a minor downdip development.

The second paper was delivered by DR. SUPRIYA ROY, of India, and was entitled *"Sedimentary Ore Bodies from the Upper Proterozoic Penanga Sequence, Andhra Pradesh, India"*. Manganese oxide ore bodies, some with nodular masses resembling modern deep sea nodules, some with manganese oxides interbedded with jasper (called "manganese-formation", in allusion to the similarity to Lake Superior-type "iron-formation"), occur interstratified with magnesian limestones, chert, jasper, and limey shale over an area greater than 200 square kilometers. Oxides interlaminated with jasper consist of todorokite, pyrolusite, and braunite, whereas ore interbedded with magnesian limestones contain ramsdellite-nsutite and birnessite-rancieite-todorokite. The deposits are considered to be of sedimentary origin partially altered during diagenesis.

DR. EUGENE ALEXANDROV, of the United States, then discussed the large-scale relationships of sedimentary manganese deposits throughout geologic time in a paper entitled *"The Genetic Convergence of Sedimentary Manganese Deposits"*. His thesis is that a metallogenic epoch, concordant with a sedimentary sequence (time-stratigraphic unit), is characterized by deposits of economic importance, low-grade deposits, and by rocks with a somewhat higher than clarke level concentrations of manganese (the two latter may be called embryonic metallogenic epochs). The accumulation of manganese in a particular time-stratigraphic unit is controlled by the environmental conditions in a given metallogenic province, and is, in principle, independent of the genetic nature of the source of the manganese. Examples from Europe, Asia, and the Americas were given, and it was suggested that an attempt be made to seek worldwide correlations of manganese deposits in sediments.

The business meeting of the Commission on Manganese was held after the last paper. The results of the meeting are summarized in a separate report.

The second technical session was held on Friday, August 18, and began with a presentation by DR. D. S. CRONAN of the paper *"Geochemistry of Ferromanganese*

Oxide Deposits from the Northwest Indian Ocean". He compared the composition of samples both from the volcanically active Carlsberg Ridge and from an adjacent range of inactive seamounts. Bulk Mn content of the Carlsberg Ridge samples was somewhat higher than in the seamount collection, but there are few significant differences between the concentrations of the other elements analyzed (Fe, Co, Ni, and Pb). Electron microprobe analyses showed distinct compositional banding in one of three samples analyzed. The variations are interpreted to indicate considerable changes in the depositional environment during the growth of this encrustation.

DR. SUNIT ADDY, also of the Unites States, then reported on the *"Manganese Nodule Deposits in the Northwest Atlantic: Their Distribution, Origin, and Prospect".* The nodule deposits in question are in the region between 25° 30′ and 29° 30′ north latitude and 58° 00 west longitude, in the abyssal hillregion of the Atlantic Ocean. The area is dominated by three deep turbidite-filled fracture valleys in the center. Mn nodules are found in varying concentrations on the abyssal hills and are absent in the fracture valleys. Maximum concentration of nodules is found between depths 5000 and 5300 meters, where the average concentration was found to be 0.75 gm/cm^2. The oxide phase in the nodules consists of birnessite and colloidal iron oxides. The detrial phase has mineralogy similar to that of the red clay substrate. Average composition of the nodules in weight percent, is 15.07 Fe, 13.03 Mn, 0.33 Ni, 0.30 Co, 0.14 Cu, and 0.057 Zn. The concentration of thorium averages 130 ppm. REE content is low compared to Pacific nodules, but relative concentrations are similar to the pattern in Pacific nodules. The Fe/Mn ratio and trace element geochemistry indicate that the nodules are predominantly hydrogenous. The deposits are not presently of economic quality, but the area is estimated to contain 240 million metric tons of nodules.

The third paper, presented by WILLIAM REINHART, of the United States, was entitled *"Metal Variations in Pacific Manganese Nodules from a Potential Deep Sea Mining Area".* The area in question is at approximately 15° 10′ north latitude, 126° west longitude, in the DOMES Site C locality. XRF analyses were reported for Mn, Fe, Ni, Cu, Co, and Zn for 159 nodules selected from 21 box cores. Nodules representative of each box core were chosen according to size, shape, and surface texture, and chemical variations were found to be somewhat greater within some box cores than from one box core to another. Average composition (weight percent) for the entire group of 159 nodules, with first standard deviation for each element, was calculated without regard for nodule size, as: Mn 25.31±4.34, Fe 6.82±1.32, Ni 1.27±0.16, Cu 0.88±0.23, Co 0.28±0.05, and Zn 016±0.05. Among the box cores which contained nodules of greatly different size, small nodules (less than about 4 cm in length) generally contained higher percentages of Mn, Ni, Cu and Zn and lower percentages of Fe and Co than larger nodules. Detailed bottom topography shows that the smaller nodules are commonly more abundant on hill crests and side slopes than in depressions, where large nodules commonly are abundant. The chief factors which influence nodule composition were found to be proportions of different types order and proportions of oxides relative to rock or clay. Nodule fragment cores predominate in the small nodules of the suite studied. In the larger nodules, clay cores are fairly common.

The fourth paper, presented by R. K. SOREM, of the United States, described observations and speculations on the physical environment of deep sea nodules and was entitled *"Nature and significance of a diffuse sediment-water interface 'boundary layer' in East Pacific manganese nodule deposits".* The observations included the appearance of manganese nodules and the associated sediment in bottom photographs and

box cores obtained during the Deep Ocean Mining Environmental Studies (DOMES) project of the U.S. National Oceanic and Atmospheric Administration (NOAA) in 1975 and 1976. Attention was called to the fact that bottom photographs show that nodules in some places are sharply outlined and seem to rest on a relatively firm substrate, whereas in other places they have a hazy outline and may be surrounded partly by a thick suspension of mud and water. Many photographs show the weak nature of this "boundary layer" by recording the effects of the camera compass as it approached or struck the bottom. The boundary layer is destroyed during collection of most box cores, but in several cores attempts to preserve it by gelling the supernatant water were partially successful. It was proposed that the presence of this sediment-rich interface boundary layer (never more than a few cm thick) of water promotes the precipitation of hydrous Mn oxides, the chief Ni- and Cu-bearing components of manganese nodules, by catalyzing the oxidation of Mn^{+2} in the manner proposed by HEM in 1963 on the basis of laboratory experiments. The slow lateral movement of such a layer could account for alternating layers or shells of crystalline Mn-rich oxides and X-ray amorphous Fe-rich oxides during nodule accretion, for nodules of a certain size ((perhaps larger than 4 cm) would tend to be covered during some periods, uncovered and exposed to sea water during others.

The next paper presented by V. P. RAKHMANOV (USSR) was concerned with localization of manganese, ferromanganese, lead, and lead-zinc ores in carbonate sediments. The paper, entitled *"Manganese ores in activated platforms"*, discussed the role of deep sub-latitudinal faults and fault conjunctions in the accumulation of metalliferous formations in the Upper Devonian of Central Kazakhstan (USSR) and at the base of the Upper Cretaceous of South Morocco. The Uspenskaya tectonic zone (USSR) extends 450 km and includes abundant sheet-like iron-manganese-barite-lead-zinc deposits in siliceous-calcareous and calcareous strata. This linear geostructure is believed to have formed in the Caledonian folded basement in the Early Hercynian epoch. In Morocco, the syngenetic lead-bearing manganese ores formed in Cenomanian-Turonian dolomites in the zone of conjunction of the Anti-Atlas (south Morocco) with the southwestern mobile branches of the High Atlas, a zone more than 100 km long. In both regions, the tectonism and igneous activity in the active zones were accompanied by basaltic eruptions. It is concluded that the metallic concentrations formed in many steps and that in some epochs metal deposition was related to tectonism.

Several other papers were submitted and accepted for inclusion in the Commission on Manganese Technical Sessions but for various reasons could not be presented with the others. The abstracts are published in the Program and Abstracts volume of the Snowbird meetings. The papers include:

CHUKHROV, F. V.: Some problems of ocean ore genesis.

HALBACH, PETER: Terrestrial formation of manganese and iron precipitates in northern latitudes.

LALOU, CLAUDE, and BRICHET, EVELYNE: Radiochemical, microchemical, and structural study of a manganese nodule from the North Pacific.

VARENTSOV, I. M.: The metalliferous sediments in Cenozoic history of sedimentation, near the crest of the Mid-Atlantic Ridge, Latitude 22°: Geochemistry and processes of formation.

ZANTOP, HALF: Trace elements in continental-volcanic iron oxides and manganese oxides: The San Francisco manganese deposit, Jalisco, Mexico. (Note: this paper was formally withdrawn by the author but was printed by the Program Committee, IAGOD).

REPORT ON BUSINESS MEETING
JAGOD COMMISSION ON MANGANESE – SNOWBIRD, UTAH

17 August 1978

by RONALD K SOREM

Members of Commission and Visitors in Attendance —

D. S. CRONAN, U. K.
S. ROY, India
R. SOREM, USA
B. MIKHAYLOV, USSR
V. RAKHMANOV, USSR
S. K. ADDY, USA
E. ALEXANDROV, USA
A. K. BANERJI, India
T. TATSUMI, Japan
W. ZIMMERNINK, FRG
W. MEYER, Canada
R. KEY, Botswana
E. VON BRAUN, UNESCO, IGCP Secretary

Agenda and Action

1. DR. VON BRAUN: Introductory comments on behalf of International Geological Correlation Programme Secretariat.
2. Reports on Commission activities since Sydney meetings.
   A. Collection, editing, and publishing manuscripts from 2nd Manganese Symposium (Sydney) in 3-volume "International Monograph on Geology and Geochemistry of Manganese", Editor-in Chief,I. M. Varentsov.
   Publication dates: Vol. 1: Late 1979
   Vol. 2: First half of 1980
   Vol. 3: First half of 1980
   B. IGCP Proj. No. 111 (see attached report).
3. Preliminary discussion for organization of Third International Manganese Symposium, to be held during 26th International Geological Congress, Paris, 1980. DR. CRONAN will make the necessary arrangements with DR. GRASSELLY (already invited by Z. JOHAN) and DR. JOHAN, co-organizer of Section 13, 26th IGC to develop the program. It was agreed that sessions on several days would probably be necessary for technical papers.
4. Announcement of resignation of DR. GRASSELLY as President of the Commission on Manganese and Leader of IGCP Project No. 111. An unanimous vote was made to express deep appreciation for DR. GRASSELLY's leadership and efforts in the past, and all present wished him a speedy and complete recovery from his recent vertebral injury. DR. GRASSELLY will remain active as Past-President and as a scientist in Proj. No. 111 work. It is hoped that he will continue his efforts to encourage and carry out a program of technical cooperation with developing countries through IGCP Proj. No. 111.
5. Election of officers. DR. CRONAN was elected our new President of the Commission on Manganese by acclamation. He accepted and nominated DR. SUPRIYA ROY as Leader of IGCP Proj. No. 111. DR. ROY was elected by acclamation and also accepted. DRS. CRONAN and ROY will work together very closely, but the separation of the Project leadership from the President's office is expected to lighten appreciably the President's responsibilities, which heretofore have been very heavy.

DR. I. M. VARENTSOV is requested to continue as Secretary of the Commission and Scientific Coordinator of Project No. 111, posts he has filled with great vigor and devotion. DRS. ROY and SOREM will continue to serve as Vice Presidents of the Commission.

6. Future activities. It was agreed that the two principal activities of the Commission during the next two years will be:

A. Plan and carry out meetings of the third International Manganese Symposium at the 26th IGC in 1980.
B. Arrange for publication of the proceedings of the Third Symposium.
C. Promote activity of all panels in IGCP Project No. 111 and arrange for technical sessions to report progress at 26th IGC.
D. Hold extensive discussions on progress and future activities of Project No. 111 panels, with emphasis on international cooperation.