Plate III Manganese Crust

- Photographs of Samples-



05SMC12AD15\_PS01~PS04



05SMC12AD16\_PS01~PS04



 $05 SMC12AD16\_PS05$ 



 $05 SMC12 AD29\_PS01$ 



05SMC12AD29\_PS06~PS07

## Plate IV Manganese Crust

- Descriptions and Micrographs of Polished Sections-

| Reflection | 00                            |   |                       | (1) (1) (1) (1) (1) (1) (1) (1) (1) (1)                | Olimn                            | Open Nicol   |                               |                |                         |   |              | Ottom  | Cross Nicol                 |              |  |            |                    | The state of the s | PI Vn: vernadite 0.1mm PI: plagioclase |
|------------|-------------------------------|---|-----------------------|--|----------------------------------|--------------|-------------------------------|----------------|-------------------------|---|--------------|--|-----------------------------|--------------|--|------------|--------------------|--|--|
|            |                               | 13cm long cross section of manganese crust. Although it is not clear but botryoidal texture of 5mm across is observed on the surface. From the surface to 8cm: Black and massive manganese oxides. Network of irregular and unclear fracture occurs entirely and limonite filling the pores of 0.5mm across is occasionally observed along the fracture. From 8cm to the end: Pale brownish gray calcareous fillings (rock fragments?) of 3 to 5mm across increases reaching to 40vol% and they occur radiating outward from inner part to surface. It has smooth surface and it does not attach to hand. |                       |  |                                  | Descriptions | Broad peak at vernadite 2.4Å. |                |                         | Clastics :<br>Quartz and plagioclase fragments of volcanic origin fill interstices of manganese oxides. | Descriptions | Volcanic origin, occurs along fracture of Mn oxides.       |                             | Descriptions | Coexists with manganese oxides in some of the fractures. |            |                    | Descriptions   |  |
|            |                               | rust. Althoug<br>From the sun<br>r fracture oc<br>dlong the frac<br>?) of 3 to 5mn<br>r part to surf  |                       |  |                                  | Abundance    | 85 %                          |                |                         | fill interstice   | Abundance    | <1 %<br>3 %  |                             | Abundance    | 2 %  |            |                    | Abundance  |  |
|            | e Crust                       | 13cm long cross section of manganese crust. Although 5mm across is observed on the surface. From the surfacoxides. Network of irregular and unclear fracture occu 0.5mm across is occasionally observed along the fracture gray calcareous fillings (rock fragments?) of 3 to 5mm they occur radiating outward from inner part to surfac attach to hand.  |                       | tted   |                                  | Grain Size   | I                             |                |                         | of volcanic origin  | Grain Size   | $0.01 \sim 0.01 \text{ mm}$<br>$0.01 \sim 0.03 \text{ mm}$ |                             | Grain Size   | I  |            |                    | Grain Size   |  |
|            | : Manganese Crust             | 13cm long cross section across section across is observoxides. Network of irro 0.5mm across is occas gray calcareous filling they occur radiating cattach to hand.  | be                    | massive to spotted<br>orm texture.                     | (vernadite)                      | Shape        | massive to spotted            |                | cope                    | ase fragments   | Shape        | fragments<br>fragments                                     |                             | Shape        | cryptocrystar<br>lline to<br>amorphous                   |            | 90                 | Shape  |  |
| 01         | Sample No.<br>Rock (ore) Name | Hand 13cm I<br>Speciment 5mm a<br>oxides.<br>0.5mm<br>gray cs<br>they oc<br>attach  | Reflection Microscope | Texture : massive to s Partly shows colloform texture. | Ore Minerals<br>Manganese oxides | Mineral      | Vernadite                     | Gangue Mineral | Polarization Microscope | Clastics:<br>Quartz and plagiocl  | Mineral      | Quartz<br>Plagioclase                                      | Matrix<br>Fe-K-Al silicates | Mineral      | tes  | Alteration | Secondary Minerals | Mineral  |  |

| Kellection                  | がなるに通じる はなるとう とうでん | r v   | 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1 |  | 0.1mm                                 | Open Nicol   |                              |                |                         |           |                 |        | 110   | Cross Nicol | ā            |            | 50                 | Vn: vern<br>PI: plagi |
|-----------------------------|--------------------|---|--|--|---------------------------------------|--------------|------------------------------|----------------|-------------------------|-----------|-----------------|--------|---|-------------|--------------|------------|--------------------|-----------------------|
|                             |                    | 13cm long cross section of manganese crust. Although it is not clear but botryoidal texture of 5mm across is observed on the surface. From the surface to 8cm: Black and massive manganese oxides. Network of irregular and unclear fracture occurs entirely and limonite filling the pores of 0.5mm across is occasionally observed along the fracture. From 8cm to the end: Pale brownish gray calcareous fillings (rock fragments?) of 3 to 5mm across increases reaching to 40vol% and they occur radiating outward from inner part to surface. It has smooth surface and it does not attach to hand. |  |  |                                       | Descriptions | Broad peak at vernadite 2.4Å |                |                         |           | Descriptions    | 1      | voicanic origin  Foraminifera of 0.2 to 0.4mm across partly occurs. |             | Descriptions |            |                    | Descriptions          |
|                             |                    | . Although it surface to 8cs cours entirely acture. From 8 increases re smooth surface  |  |  |                                       | Abundance    |                              |                |                         |           | Abundance       | -      |   |             | Abundance    |            |                    | Abundance             |
| 5 PS03                      | Cr                 | of manganese crusi<br>e surface. From the<br>dunclear fracture o<br>sserved along the fr.<br>?) of 3 to 5mm acros<br>t to surface. It has s   |  | form<br>le.  |                                       | Grain Size   | I.                           |                |                         |           | Grain Size      | В      | $0.01 \sim 0.03$<br>$0.1 \sim 2$ mm                                 |             | Grain Size   |            |                    | Grain Size            |
| 05SMC12AD15                 | : Manganese Crust  | ng cross section<br>s observed on th<br>k of irregular an<br>s occasionally ob<br>(rock fragments<br>d from inner par   | be                                       | Spotted to colloform   | dite)                                 | Shape        | spotted to                   |                | cope                    | 1         | Shape           |        | ragments<br>sub-angular   |             | Shape        |            |                    | Shape                 |
| Ser. No. 03<br>Sample No. ( | Vame               | Hand 13cm lo Speciment across is Networt across is fillings   | Reflection Microscope                    | Texture Spotted to collofo<br>Partly shows stripes of 0.02cm wide. | Ore Minerals<br>Mn Oxides (vernadite) | Mineral      | Vernadite                    | Gangue Mineral | Polarization Microscope | Clastics: | Wineral Mineral | Quartz | riagiociase<br>Limestone  | Matrix      | Mineral      | Alteration | Secondary Minerals | Mineral               |

Vn: vernadite Pl: plagioclase Cf: calcareous fragment

| Ser. No. 04                                  |  |  |  |   | Reflection  |
|--|--|--|--|---|---|
| Sample No.                                   | 05SMC12AD15  | 5 PS04   |  |   | 1100年の日本の日本の日本の日本の日本の日本の日本の日本の日本の日本の日本の日本の日本の   |
| Rock (ore) Name                              | : Manganese Crust  | se Crust   |  |   |   |
| Hand 13cm 1 Speciment across Netwo           | is observed on the observed of the observed on | 13cm long cross section of manganese crust. Although it is not clea across is observed on the surface. From the surface to 8cm: Black a Network of irregular and unclear fracture occurs entirely and limo across is occasionally observed along the fracture. From 8cm to the | ist. Although i<br>he surface to 8<br>cocurs entire,<br>fracture. From | 13cm long cross section of manganese crust. Although it is not clear but botryoidal texture of 5mm across is observed on the surface. From the surface to 8cm: Black and massive manganese oxides. Network of irregular and unclear fracture occurs entirely and limonite filling the pores of 0.5mm across is occasionally observed along the fracture. From 8cm to the end: Pale brownish gray calcareous |   |
| niing<br>outwa                               | s (rock tragment<br>rd from inner pa   | nings rock tragments?) of 5 to 5mm across increases reaching to<br>outward from inner part to surface. It has smooth surface and it do   | oss increases i<br>s smooth surfa                                      | nings rock tragments?) of 5 to 5mm across increases reaching to 40vot% and they occur radiating outward from inner part to surface. It has smooth surface and it does not attach to hand.   |   |
| Reflection Microscope                        | obe  |  |  |   |   |
| Texture Collofo<br>partly spotted to network | Colloform  |  |  |   |   |
|  |  |  |  |   |   |
| Ore Minerals                                 |  |  |  |   |   |
| manganese oxides (vernadite)                 | (vernadite)  |  |  |   | THE RESERVE TO SERVE |
| Mineral                                      | Shape  | Grain Size   | Abundance  | Descriptions  | Open Nicol  |
| Vernadite                                    | colloform  | I  | % 92   | Broad peak at vernadite 2.4Å.   |   |
| Gangue Mineral                               |  |  |  |   |   |
| Polarization Microscope                      | scope  |  |  |   |   |
| Clastics:<br>Quartz and plagioo              | clase of volcanic  | origin are scatter   | rd in Mn oxid  | Clastics :<br>Quartz and plagioclase of volcanic origin are scatterd in Mn oxides. Fragments of limestone occur in fracture.  |   |
| Mineral                                      | Shape  | Grain Size   | Abundance  | Descriptions  |   |
| Quartz                                       | fragments  | 0.02 ~ 0.08 mm   | 2 %  | volcanic origin, also found in limestone  | \$ 5  |
| Plagioclase<br>Limestone                     | 00   | <0.03 mm 0.02 ~ 0.1 mm   | 20 %   | volcanic origin, also found in limestone<br>Found in fracture. Foraminifera included.   |   |
| Matrix                                       |  |  |  |   | Cross Nicol   |
| Mineral                                      | Shape  | Grain Size   | Abundance  | Descriptions  |   |
| 0  |  |  |  |   | JO  |
| Alteration                                   |  |  |  |   |   |
| Secondary Minerals                           | B  |  |  |   |   |
| Mineral                                      | Shape  | Grain Size   | Abundance  | Descriptions  |   |
|  |  |  |  |   | Vn: vernadite 0.1 mm CF calcareous fragment   |
|  |  |  |  |   |   |

| Reflection                  |      | us.  |                       |  | からない とうなる からいにはる 一般です | null of                      |                      | Open Nicol      |                |                         |           |  |                      |                                |        | Cross Nicol |                      |            | Id                 |                      | Vn: vernadite 0.1 m/m Pl: plagiodase |
|-----------------------------|------|--|-----------------------|--|-----------------------|------------------------------|----------------------|-----------------|----------------|-------------------------|-----------|--|----------------------|--------------------------------|--------|-------------|----------------------|------------|--------------------|----------------------|--------------------------------------|
|                             |      | 13cm long cross section of black to pale brownish gray manganese crust. The surface shows botryoidal texture of 2cm across. From the surface to below, the amount of irregular shaped patch to network of pale brownish gray calcareous fillings (rock fragments?) increases to 30 vol. %. Pores of 1mm across are rare and unclear 2 to 3mm wide network of limonite is scattered entirely. It has smooth surface and it does not attach to hand. |                       |  |                       |                              | Descriptions         | Broad peak at v |                |                         |           | nanganese oxides.  | Descriptions         | volcanic origin                |        |             | Descriptions         |            |                    | ce Descriptions      |                                      |
| PS01                        | it   | 13cm long cross section of black to pale brownish gray mangar botryoidal texture of 2cm across. From the surface to below, th patch to network of pale brownish gray calcareous fillings (roc %. Pores of 1mm across are rare and unclear 2 to 3mm wide n entirely. It has smooth surface and it does not attach to hand.  |                       |  |                       |                              | Grain Size Abundance |                 |                |                         |           | Quartz and plagioclase of volcanic origin occur in fractures of manganese oxides | Grain Size Abundance | $0.01\sim0.03~\mathrm{mm}$ 2 % | -      |             | Grain Size Abundance |            |                    | Grain Size Abundance |                                      |
| 05SMC12AD16 P               | C    | ong cross section of b<br>idal texture of 2cm ac<br>to network of pale bro<br>es of 1mm across are<br>y. It has smooth surfe   | 90                    | massive to spotted<br>orm texture.                   |                       | (vernadite)                  | Shape Gr             |                 |                | cope                    |           | lase of volcanic origin  | Shape Gr             | œ                              |        | -           | Shape                |            |                    | Shape Gr             |                                      |
| Ser. No. 05<br>Sample No. ( | Vame | Hand 13cm l Speciment botryoi patch t %. Por   | Reflection Microscope | Texture massive to s Partly shows colloform texture. | Ore Minerals          | manganese oxides (vernadite) | Mineral              |                 | Gangue Mineral | Polarization Microscope | Clastics: | Quartz and plagioc   | Mineral              | Plagioclase                    | Matrix |             | Mineral              | Alteration | Secondary Minerals | Mineral              |                                      |

| botryoidal texture of 2em across. From the surface to below, the amount of irregular shaped patch to network of pale brownish gray calcareous fillings (rock fragments?) increases to 30 vol.  %. Pores of 1mm across are rare and unclear 2 to 3mm wide network of limonite is scattered entirely. It has smooth surface and it does not attach to hand.  icroscope  i. Spotte to Colloform  i. network.  Saxides (vernadite)  Shape  Grain Size  Abundance  Descriptions  Spotte to  Spotte to  O03 ~ 0.05 mm  1 % Found in pores. | - Col.              |
|--|---------------------|
| Descriptions Broad peak at vernadite 2.4 Å Found in pores.   | ocurs.              |
|  | ocurs.              |
|  | Occurs.             |
|  | occurs.             |
|  | Ocurs.              |
|  | occurs.             |
| ores.  | occurs.             |
|  | occurs.             |
|  | ocurs.  e oxides.   |
|  | occurs.  le oxides. |
| Clastics : Plagioclase and quartz of volcanic origin occur in fracture of Mn oxides and around limestone fragment.   | occurs.  e oxides.  |
| l limestone fragment.  Descriptions  | G Sea               |
| s and around limestone fragment.  Descriptions Volcanic origin nosaic texture  |                     |
| s and around limestone fragment.  Descriptions Volcanic origin, mosaic texture Foraminifera of 0.1mm across occurs.  |                     |
| occurs.  | Descriptions        |
| ocurs.  le oxides.   | Descriptions        |
| ocurs.   | Descriptions        |
| ocurs.   |                     |

| Reflection                     |      | U.A.   |                       |   |  |                      | Open Nicol    |                |                         |  |                      |                                 | WILLIAM STATE OF THE STATE OF T | Cross Nicol                 | のという。                | To the state of th |            |                    | Vn: vernadite        |
|--------------------------------|------|--|-----------------------|---|--|----------------------|---------------|----------------|-------------------------|--|----------------------|---------------------------------|--|-----------------------------|----------------------|--|------------|--------------------|----------------------|
|                                |      | 13cm long cross section of black to pale brownish gray manganese crust. The surface shows botryoidal texture of 2cm across. From the surface to below, the amount of irregular shaped patch to network of pale brownish gray calcareous fillings (rock fragments?) increases to 30 vol. %. Pores of 1mm across are rare and unclear 2 to 3mm wide network of limonite is scattered entirely. It has smooth surface and it does not attach to hand. |                       |   |  | Descriptions         | Broad peak at |                |                         | Clastics:<br>Plagioclase and quartz of volcanic origin occur in fracture of Mn oxides and around limestone fragment. | e Descriptions       | Volcanic origin Volcanic origin | Scattered in Mn oxides, includes foraminiera. Includes plagioclase of 0.02~0.03mm across   |                             | Descriptions         | Coexists with Mn oxides.   |            |                    | Descriptions         |
| 83                             |      | 13cm long cross section of black to pale brownish gray mangai botryoidal texture of 2cm across. From the surface to below, th patch to network of pale brownish gray calcareous fillings (roc %. Pores of 1mm across are rare and unclear 2 to 3mm wide n entirely. It has smooth surface and it does not attach to hand.  |                       | exture.   | te   | Grain Size Abundance |               |                |                         | in fracture of Mn oxid   | Grain Size Abundance |                                 | 6 mm 20 %<br>0.2 mm <1 %   |                             | Grain Size Abundance | 2 %  |            |                    | Grain Size Abundance |
| 05SMC12AD16 PS03               | C    | ross section of blackexture of 2cm acrostwork of pale brown 1mm across are ranhas smooth surface   |                       | Spotted to network. Partly shows colloform texture. | nadite) , magnetite                          | Shape                | 0             |                |                         | volcanic origin occur  | Shape Grain          | 00                              | shapless $0.3 \sim 6$<br>sub-angular 0.3 $\sim 6$  |                             | Shape Grain          | cryptocrysta –   |            |                    | Shape Grain          |
| Ser. No. 07<br>Sample No. 05SN | Vame | Hand 13cm long c Speciment botryoidal t patch to nei %. Pores of entirely. It  | Reflection Microscope | Texture Spot<br>Part                                | Ore Minerals<br>manganese oxides (vernadite) | Mineral              | spo           | Gangue Mineral | Polarization Microscope | Clastics:<br>Plagioclase and quartz of   | Mineral              |                                 | Lamestone sh<br>Volcanic rock sub  | Matrix<br>Fe-K-Al Silicates |                      | Fe-K-Al Silicates cryptocryst<br>lline to  | Alteration | Secondary Minerals | Mineral              |

| Reflection                |                   |  |                       |   | 1mr.0  |              | Open Nicol                    |                |                         |   |              |  |                               | Cross Mcol      |  |            |                    | Pl  Vn: vernadite  0.1 mm Pl: plagioclase |
|---------------------------|-------------------|--|-----------------------|---|--|--------------|-------------------------------|----------------|-------------------------|---|--------------|--|-------------------------------|-----------------|--|------------|--------------------|---|
|                           |                   | 13cm long cross section of black to pale brownish gray manganese crust. The surface shows botryoidal texture of 2cm across. From the surface to below, the amount of irregular shaped patch to network of pale brownish gray calcareous fillings (rock fragments?) increases to 30 vol. %. Pores of 1mm across are rare and unclear 2 to 3mm wide network of limonite is scattered entirely. It has smooth surface and it does not attach to hand. |                       |   |  | Descriptions | Broad peak at vernadite 2.4Å. |                |                         |   | Descriptions | Volcanic origin Volcanic origin Scattered in fracture of Mn oxides. Includes | Foraminiera of ~0.2mm across. | Descriptions    | Coexists with Mn oxides.               |            |                    | Descriptions                              |
|                           |                   | brownish grathe surface tralcareous finclear 2 to 3n oes not attac   |                       |   |  | Abundance    | % 09                          |                |                         | re of Mn oxide  | Abundance    | <1 %<br>5 %<br>25 %  |                               | Abundance       | 3 %                                    |            |                    | Abundance                                 |
| 3 PS04                    | ပ်                | 13cm long cross section of black to pale brownish gray mangar botryoidal texture of 2cm across. From the surface to below, th patch to network of pale brownish gray calcareous fillings (roc? %. Pores of 1mm across are rare and unclear 2 to 3mm wide neutirely. It has smooth surface and it does not attach to hand.  |                       | Spotted to network<br>Partly shows colloform texture. |  | Grain Size   | ţ                             |                |                         | gin occur in fractur  | Grain Size   | $\frac{\sim}{0.06 \text{ mm}}$ 0.02 $\frac{\sim}{\sim}$ 0.03 mm $\sim$ 2 mm  |                               | Grain Size      |  |            |                    | Grain Size                                |
| 05SMC12AD16               | : Manganese Crust | long cross sectic<br>pidal texture of 1<br>to network of pr<br>res of 1mm acros<br>ly. It has smootl   | ope                   | Spotted to network<br>Partly shows collof             | (vernadite)                                  | Shape        | Spotted to<br>network         |                | scope                   | rtz of volcanic ori   | Shape        | ess  |                               | Shane           | cryptocrystar<br>lline to<br>amorphous |            | Is                 | Shape                                     |
| Ser. No. 08<br>Sample No. | Rock (ore) Name   | Hand 13cm<br>Speciment botryc<br>patch<br>%. Por   | Reflection Microscope | Texture :   | Ore Minerals<br>manganese oxides (vernadite) | Mineral      | Vernadite                     | Gangue Mineral | Polarization Microscope | Clastics :<br>Plagioclase and quartz of volcanic origin occur in fracture of Mn oxides. | Mineral      | Quartz<br>Plagioclase<br>Limestone   | Matrix                        | Mineral Mineral | Fe-K-Al Silicates                      | Alteration | Secondary Minerals | Mineral                                   |