XV. X-RAY MINERALOGY OF MANGANESE NODULES FROM THE GH78-1 AREA

Mehmet Fakioglu, Makoto Yuasa and Tomoyuki Moritani*

Method

Experiments were carried out for both the shells and the cores of manganese nodules. Instrumental conditions were continuously changed for different nodules considering the degree of crystallinity, purity and the level of the examined part of the nodule. Rigaku Denki diffractometer was used for the work. Samples were examined using Fe Kα radiation at 12–16 mA and 20–30 kV. The most suitable condition for the majority of the manganese shells was observed to be 14 mA and 25 kV, and slightly deviated from these values for the cores. Fe Kα radiation was eliminated by Mn-filter. Scanning speed of 2°/min, wide time constant range varying between 2 and 16 sec, and generally 0.6 mm wide receiving slit for concentric shells and 0.3 mm wide one for cores were used. The mineral powder did not pass through any process i.e. heating.

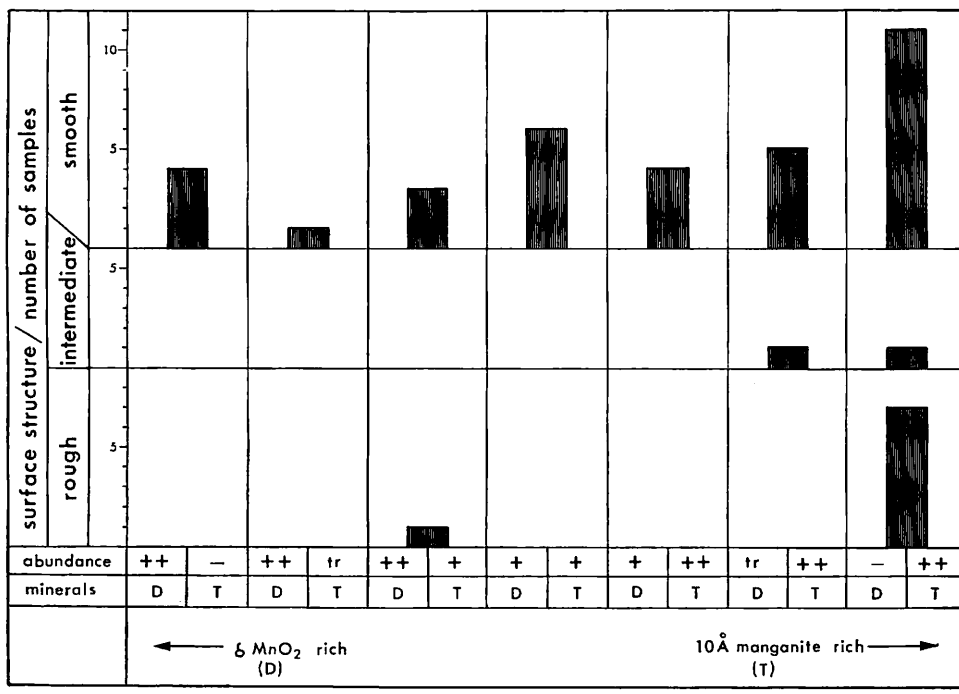

Fig. XV-1 Relation between mineral composition and surface structure. Abundance of minerals is expressed on the basis of peak height only.

* Mineral Research and Exploration Institute, Ankara, Turkey

Table XV-1 X-ray mineralogical

Station No.	Observation No.	Examined portion	"X"	Minerals				
				10A	dMn	Q	F	Others
1036	G(B)604	Outermost shell	B	++	+	+	—	+
		Inner shell	B	+	+	+		+
	F G74-2	Shells	F	—	++	+	—	—
1057	G(B)605-1	Outer shell	B	+	+	+	—	+
1040	G(B)608	Outer shell	B	+	+	+	—	+
1043	G611	Outer shell	VG	++	—	+	—	—
	F G80-1	Outer shell	VG	++	—	+	+	—
1044	G612							
	F G81-1	Outer shell	G	++	T	+	—	+
	F G81-2	Outer shell	G	++	T	+	—	+
1045	G613	Outer shell	F	+	++	++	—	+
1046	G614	Surficial grains	VG	++	—	++	—	—
		Outer shell	F	++	T	++	—	+
1047	G615	Outer shell	G	++	—	+	—	—
1048	G(B)616	Surficial grains	VG	++	—	+	—	—
		Outer shell	F	++	—	+	—	—
	F G85-2	Outer shell	B	++	+	+	—	+
1048-1	G616-1	Shells	G	—	++	+	—	—
1049	G617	Outer shell	VG	++	T	+	—	—
1050	G618	Outer shell	B	++	—	+	+	+
	F G87-1	Shells	G	++	++	+	—	—
1051	G619	Outer shell	G	++	—	+	—	—
1052	G620	Shells	G	++	+	+	—	—
1053	G621	Small nodule(Mn)	B	+	+	+	+	+
1054	G622	Out. sh. (round. gr)	F	+	++	+	—	—
		Out. sh. (platy gr)	F	—	++	+	—	+
	F G91-2	Outermost shell	F	—	++	+	—	+
		Inner shell	F	—	++	+	—	+
1060	G(B)623	Shells	F	++	—	+	+	—
	F G92-1	Shells	F	++	—	+	—	+
1061	G(B)624	Surficial grains	VG	++	—	+	—	—
1055	G(B)625	Outer shell	G	++	—	+	+	+
	F G94-1	Small nodule	VG	++	—	+	—	—
1056	G(B)626	Surficial grains	VG	++	—	+	—	—
		Outer shell	F	++	+	+	—	—
	F G95-1	Shells	G	++	+	+	—	+
	F G95-2	Surficial grains	VG	++	—	+	—	—
		Shells	F	++	T	+	+	+
1057	F G96-1	Shells	G	++	+	+	—	—
	F G96-2	Outer shell	VG	++	—	+	—	—
1057-2	G627-2A	Surficial grains	G	++	—	+	T	—
	G627-2B	Outer shell	G	++	—	+	+	—
1059	G629	Surficial grains	VG	++	—	+	—	—
		Inner shells	G	++	—	+	—	+

composition of manganese nodules

Examined portion	"X"	Minerals							
		10A	dMn	Q	F	Z(P)	Z(C)	Mon	Others
Core	B	−	−	T	T	−	++	−	+
Core	G	−	−	+	+	++	+	−	+
Platy fragment	VG	T	−	++	−	−	−	−	−
Core	VG	−	−	T	+	++	+	T	T
Fragment	VG	−	−	T	+	++	+	T	+
Fragment	VG	−	−	−	+	++	+	+	+
Core	G	−	−	+	+	++	+	+	+
Core	G	T	−	T	T	++	++	−	+
Core	G	−	−	+	−	+	−	++	−
Core	B	++	−	+	−	−	−	−	+
Core	G	T	T	−	++	T	−	−	+
Core	G	−	−	+	−	+	−	++	+
Core Yellowish nodule	G	++	++	+	−	−	−	−	−
Core	VG	−	−	−	++	−	−	−	−
Crust	G	−	−	−	++	++	−	−	+
Core (platy grain)	VG	−	−	++	−	−	−	−	+
Core	G	−	−	−	−	−	−	++	−
Core	G	++	−	+	+	−	−	−	+
Core	VG	++	−	+	+	−	—	−	−
Platy fragment	VG	+	−	++	−	−	−	—	−
Core	F	−	−	T	T	+	T	++	−
Core	G	++	++	+	−	—	—	−	−
Core	F	++	−	+	−	−	−	−	+
Core (Elongated)	G	−	−	+	++	−	−	++	+

Table XV-1

Station No.	Observation No.	Examined portion	"X"	Minerals				
				10A	dMn	Q	F	Others
1064	F G100-2	Small nodule	F	+	+	+	+	+
		Out. sh. (irr. shape)	G	++	−	T	−	−
1065	G632	Shells	G	++	−	+	−	−
	F G102-2	Outer shell	B	+	−	+	+	+
	F G102-2	Outer shell	B	−	++	+	−	+
1068	F G104	Outer shell	B	++	−	+	−	+
1071	G637	Shells	F	++	+	+	T	−
1073	F G109-6	Outer shell	B	+	++	++	−	+
1074	F G110-1	Outer shell	B	+	+	+	+	+
	F G110-2	Outer shell	B	+	−	+	−	+
1039-A	G641	Outer shell	F	++	−	+	−	−
	F G114-1	Outer shell	F	+	−	−	−	+

"X".....Crystallinity
B: Bad
F: Fair
G: Good
VG: Very good

Minerals:
10A : 10 Angstrom manganite
dMn : "Delta" MnO_2
Q : Quartz
F : Feldspar

Results

Shells

Studies of the present manganese nodules, have shown that the principal manganese minerals were 10Å manganite and δ-MnO_2. As it will be observed easily from Table XV-1. 10Å manganite is dominant or at least present on the majority of the samples. Quartz is also observed to be present almost in all of the samples. Feldspar on the contrary seems to be absent or trace element of the shells in general. It was quite difficult to determine the exact composition of feldspar, but it is observed to be nearer to high sanidine, andesine and sometimes labradorite. Goethite and lepidocrosite are observed to be trace elements in some shells and especially in the impure crust of sample, No. FG 114-1. Zeolites and some other silicates also seem to be present in some of them.

Cores

The studied cores can be classified into four calsses according to the abundant component, in a broad sense.

a) Zeolite cores
b) Cores of manganese minerals
c) Quartz cores
d) Montmorillonite cores

a) *Zeolite cores*: They form the most of the cores and mainly two zeolite minerals (phillipsite and clinoptilolite) are distinguished. As it can be seen from the Table XV-1, they show good crystallinity. Both of the elements are present

(Continued)

Examined portion	"X"	Minerals							
		10A	dMn	Q	F	Z(P)	Z(C)	Mon	Others
Core (irr. shape)	F	−	−	−	+	++	−	−	+
Core									
Core	G	−	−	−	−	−	−	++	−
Core	F	−	−	−	T	++	++	+	−
Core	G	−	−	T	T	++	+	+	+
Core	G	−	−	−	+	++	+	+	−
Core	G	−	−	T	+	−	++	−	++

Z(P) : Zeolite (phillipsite)
Z(C) : Zeolite (clinoptilolite)
Mon : Montmorillonite
Others: Ca-Al-Si-hydrate, K-Mg-silicate, geothite, lepidochrosite, and undetermined of mainly minerals listed above.

Abundance:
++ : Predominant
+ : Dominant
T : Trace
− : Not detected

in the majority of the cores of this group and phillipsite is more abundant in general. Almost pure clinoptilolite is observed in cores of samples, G(B)604 and FG110-2. Impurities of manganese minerals, quartz, feldspars, montmorillonite and undetermined other minerals or mixtures all generally present.

b) *Cores of manganese minerals*: The more dominant one here also seems to be 10Å manganite but it should be noticed that δ-MnO_2 is more abundant than it is in the shells. Impurities especially of quartz are present.

c) *Quartz cores*: They are generally platy shaped fragment with very thin cover of manganese minerals. Therefore it was impossible to separate the core from the thin crust.

d) *Montmorillonite cores*: The best differentiated clay mineral was montmorillonite especially in purest cores of samples, FG91-2 and FG102-2.

Discussion

Different layers of some nodules, especially those having irregular surface morphology are studied and the results show that there is an increase in purity and degree of crystallinity of the Mn-minerals from the center outwards. That fact can be observed clearly on the nodules taken from stations 1046, 1098, 1054, 1056 (for two different samples) and 1059.

A correlation has been done between the sea bottom topography and the composition of manganese minerals. Samples those are taken from near the bottom of the seamount slopes are observed to be richer in δ-MnO_2 content.

Striking examples of this attitude are stations 1054, 1048, 1045, 1073, 1036 and 1050. Relative increase in δ-MnO_2 content towards the center when surficial grains and shells are considered is another noticeable point. That also can be seen in samples taken from stations, 1036, 1046 and 1056.

It is difficult to state a similar tendency for the nodules having Mn-mineral cores when core and crustal parts are considered. There is no noticeable variation in composition in general; and if present as in the nodules taken from stations, 1048 (FG85-2) and 1052, the variation in composition is not one dimentional. However it can be said that the crystallinity is somewhat better in outer parts with a unique exception at the station 1055.

Another correlation is done for the morphology of the nodules and the composition of Mn-minerals. Since it is impossible to give an exact definition for roughness or smoothness of the nodule surface they are first classified relative to each other as smooth, intermediate and rough surfaced nodules, and as seen on Fig. XV-1 it is observed that although the smooth surfaced nodules have a wide range of composition, the rough surfaced ones are in 10Å manganite composition with only one exception.