Chapter 6 Discussion

6-1. Interpretation of the anomalies of airborne geophysical survey

6-6-1. MJNM-1,5,6,7,8,9 and 10 East of the survey area

Fig. II-6-1(1) illustrates relationships between the result of drilling survey and the geophysical anomalies particularly airborne aeromagnetic method used in Phase II. General view allows the geological structure to be two layer-structure being composed of surficial calcrete 100 to 120 metre deep combined with Kalahari sand and underlying Damara carbonates or basement rocks.

The calcrete had been esteemed to be of comparatively high resistivity. However, percussion drilling revealed that it hosted some argillized aquifers within 100 metre thickness giving such calcrete low resistivity enough. Although resistivity map of 56000 Hz generally shows deeper resistivity structure of shallow depth, the difference of anomaly patterns between 7200 Hz and 900 Hz the observed values of resistivity, may indicate 56000 Hz map project the resistivity structure at a depth of 60 metre or within calcrete as illustrated in resistivity profile in Phase II report. The sand is a terrestrial sediment of paleo Kalahari desert. The quartz grains are filled with a large amount of reddish argil and shows remarkably low resistivity when the water percolates in it. It lies 100 to 120 meter deep and is possibly translated to a partly 7200 Hz resistivity structure. It looks like extending to the north of the synclinal axis which is formed in the carbonate sequences. These young sediments is unconformably underlain by mainly dolomite, limestone and chert which shows high resistivity.

The holes of MJNM-5,6 and 7 are spot anomalies on a low resistivity lineament traversing northwesterly the synclinorium with E-W trending axis. The drilling survey showed lineament could be deep-seated ruptured zone along which a swarm of dolerite dykes of pre-Tertiary age intruded. Core logging indicated the dolerite dips 45 to 60 degree and is subjected to intense hydrothermal alteration forming a great deal of talc. Only MJNM-7 of the holes drilled on the low resistivity lineament intersected the dolerite dyke, however the interpretation combined with the aeromagnetic anomalies would show that the dolerite could run intermittently in parallel with the low resistivity lineament. MJNM-8 and MJNM-10 intersected the dolerite dykes at the same depth. The dykes are possibly a pair of parallel dyke swarm.

The key depth of resistivity structure 900 Hz may vary with resistivity values of the formation, but the resistivity profile of Phase II combined with the result of the drilling survey indicates that the map account for the structure at a depth of 200 to 250 metre. That may translate that the geological structure including dolomite dominant formation may be responsible to 900 Hz resistivity map.

MJNM-5 intersected some cavities filled with a large amount of water and clay. It is believed that the low resistivity anomalies of 7200 and 900 Hz at the vicinity of MJNM-5 was enhanced by such sources of low resistivity. Such cavities are believed to be one of the most preferable criteria for loci of ore deposition. From a viewpoint of timing of ore formation, this potential cavities should have been filled

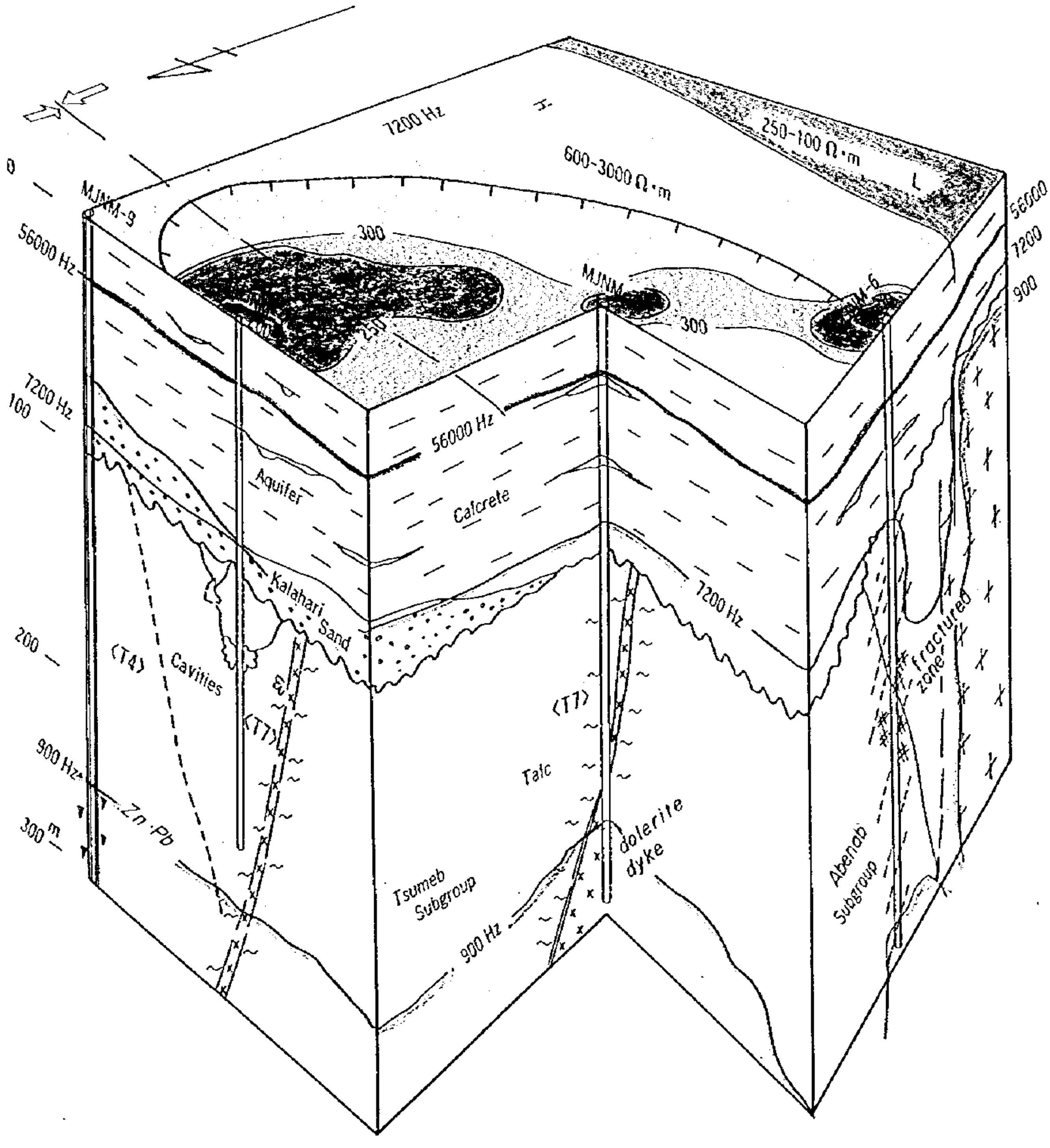

Fig. II −6−1(1) Model block map of compilation and interpretation

with molasse sand of the Mulden group. Therefore, the cavities of MJNM-5 filled with clay and water is believed to be far young than potential mineralisation. The cavities may be possibly formed through circulation of ground water into argillaceous zone resulted from hydrothermal alteration at the time of intrusion of dolerite dykes.

6-1-2. MJNM-11,12 West of the survey area

The relationship between the result of drilling and the result of airborne electromagnetic survey of the Phase II was illustrated in Fig. II -6-1(2). The anomaly pattern of the area varies with the depth. The low resistivity zones are more widely extended and the observed values are lower at the shallower depth(56000 Hz) than at the deeper depth(7200 and 900 Hz). The characteristics of the shallower layer at 56000 Hz are remarkable NNE-SSW trending lineaments, however at 7200 Hz ENE-WSW becomes more obvious instead of NNE-SSW and both of ENE-WSW and NW-SE trending lineament at 900 Hz.

MJNM-11 was targeted at the intersection of the two lineaments. One is ENE-WSW trending low resistivity lineament and the other is NNE-SSW trending low resistivity.

MJNM-12 was sunk at the center of isolated low resistivity window within high resistivity zone. The resistivity profile calculated from differential resistivity gives the depth of 10-20 metres for 56000 Hz and 50-100 metres for 7200 Hz respectively.

The interpretation combined with the result of drilling survey indicates that the low resistivity anomalies may be caused by ruptured zone running through up to calcrete, pyrite disseminated in the sandstone of Mulden group, weathered zone of the formation or intercalated shale beds. Although the pyrite is most likely source of low resistivity, that contradicts obviously the fact that the sandstone is encountered commonly in both holes and that the pyrite shows syndepositional origin and also that MJNM-12 is located at the isolated low anomaly.

The hole of MJNM-11 intersected intensely fractured zone with black dolomitic shale beneath Mulden unconformity suggesting ENE striking fault which may pass near the Tsumeb ore deposit. If the fault would dislocate the formation up to the Mulden sandstone it could be a source of low resistivity at 7200 Hz. The NNE-SSW trending resistivity lineament at 56000 Hz may coincides with the direction of groundwater channels within calcrete in this area.

6-1-3. MJNM-2,3,4 Other areas

The holes of MJNM-1 and MJNM-2 in the east of the survey area and the holes of MJNM-3 and MJNM-4 of the central area, were located targeting the isolated aeromagnetic anomalies of the Phase I . The location of MJNM-2 is plotted near the border of the high resistivity zone and the low resistivity zone which extend easterly to the north of the basement terrain. The weak resistivity lineament traverses north to south near the hole through the basement.

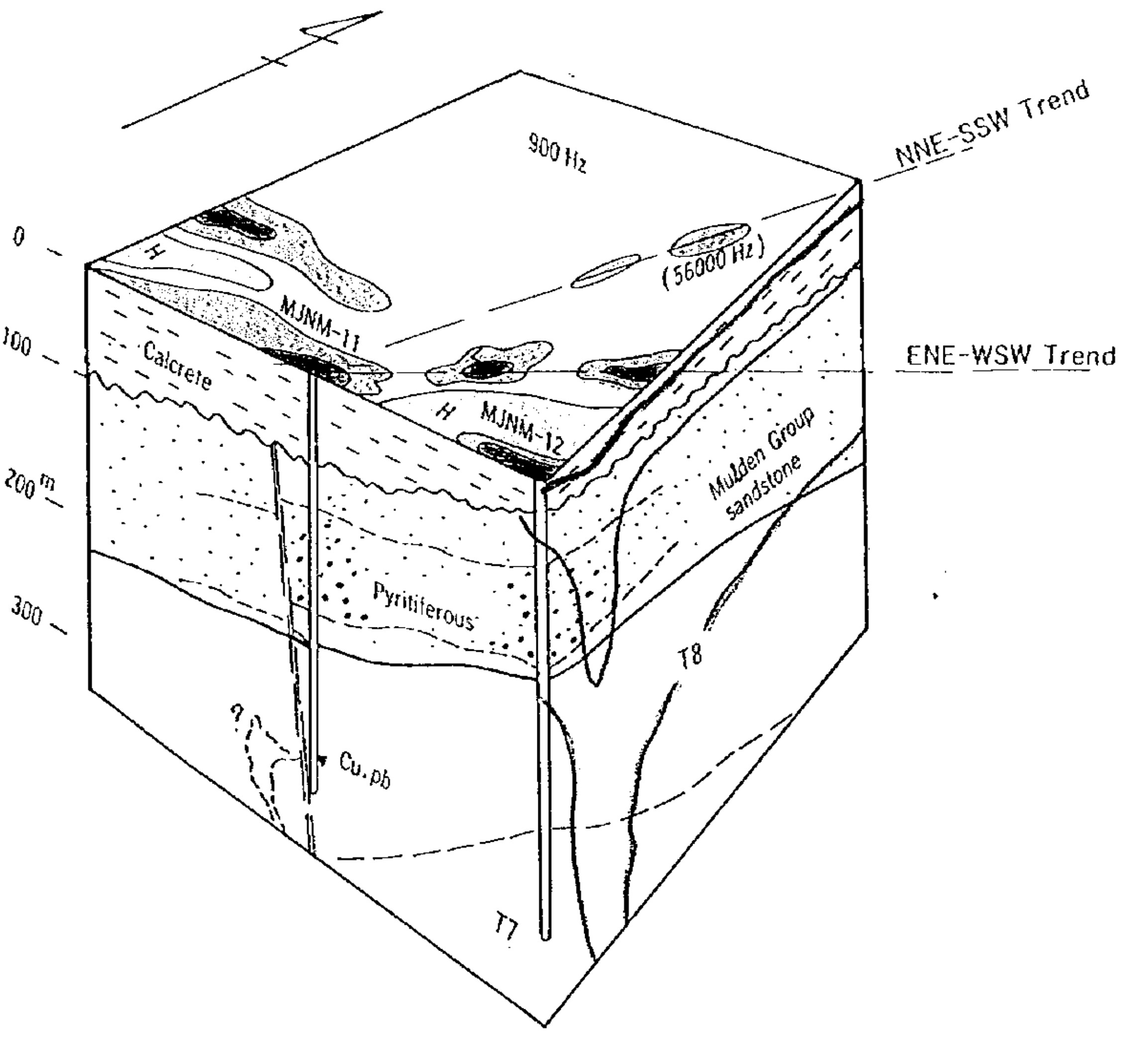

Fig. II −6−1(2) Model block map of compilation and interpretation

While the MJNM-3 is enclosed within the high resistivity zone with E-W trend which may suggest an anticlinorium, the MJNM-4 is situated on the border of the broad high resistivity zone and the low resistivity zone. The hole of MJNM-1 was mentioned in 6-1-1.

6-2. Compilation and Interpretation

In phase Ⅲ, eight holes totaling 2,320 metres were drilled using the exploration model prepared on the basis of the results of Phase I and Phase II survey which consisted of compilation of the previous exploration, airborne geophysical survey and wide spaced drilling.

The hole of MJNM-9 intersected an extension of the medium to weak lead and zinc mineralisation of so called Mississippi Valley Type which was encountered in MJNM-1 of Phase II. The average grade of Pb combined with Zn over 5.24m of cumulative length of mineralised section was 0.129 % and low compared to MJNM-1. The mineralisation is hosted within grainstone as MJNM-1 suggesting stratigraphic control of T4.(Fig. II-6-1(1))

Intense pyrite mineralisation was intersected by both holes of MJNM-11 and MJNM-12 within sandstone of Mulden group. Chemical assay revealed the pyrite was not associated with copper concentration. The occurrence of pyrite showed syndepositional origin under reducing environment. Whereas MJNM-11 which was targeted on the intersection of ENE-WSW trending low resistivity lineament with NNE-SSW trending lineament, encountered a copper-lead-vanadium mineralisation associated with dolospar and calcite veinlets hosted within T8 dolomite. This mineralisation could be grouped into Tsumeb type ore rather than Mississippi Valley Type from a viewpoint of metal ratio which indicated high concentration of copper compared to lead and zinc. This weak mineralisation was believed to be hosted at the tip of an intensely fractured zone. A potential ore deposit could be expected towards extension of the fracture zone which would lead to karst breccias and therefore further exploration is recommended in the future.(Fig. II-6-1(2))

No mineralisation was encountered on the low resistivity lineaments or spots traversing the Mulden group unconformity which accounted for the exploration rationale. The drilling revealed that the low resistivity lineaments might coincide with NW-SE trending dolerite dykes and with hydrothermal alteration including talc argillization. No low resistivity spots so far drilled coincided with any karst breccias and solution breccias.

The Mulden sandstone had been expected to underlay widely in the east of the survey area based upon interpretation of resistivity map combined with aeromagnetic anomaly map the drilling however, intersected no sandstone there. Therefore an ore potential under the Mulden unconformity were not tested enough. For more detailed exploration of potential karst structure in the Mulden group terrain, such a ground geophysical survey as TDEM would be needed with narrower-spaced survey line prior to drilling.

In the west of the survey area, the sandstone of Mulden group was intersected over more than 100m where it had not been expected on the basis of image interpretation and airborne geophysical data.(Fig. II-6-1(2)) That explains limited interpretation of the underlying formation using resistivity map. Particularly, in the east of the survey area, the Kalahari sand could be a source of low resistivity at a shallow depth, possibly masking the low resistivity anomalies which might be originated from potential ore.(Fig. II-6-1(2))

Thus there could be various sources of low resistivity anomaly including aquifer and clay minerals formed during weathering process at a shallower depth which may reflect on the deeper structure of resistivity. In other words, practically the lower frequency may receive the signals of a shallower depth and that may make the deep exploration less effective.

Nonetheless, an airborne geophysical survey is believed to be most favourable because of high efficiency of data acquisition and cost performance in such an area poorly exposed like Otavi mountainland area. An aeromagnetic combined with an airborne electromagnetic survey could give detailed analysis and interpretation. But the detailed physical properties of surface sediments and consideration of the key depth would be inevitable for the survey.

Part III Conclusion and Recommendation

Part III Conclusion and recommendation

Chapter 1 Conclusion

This survey included a compilation of the previous work followed by geological mapping, an airborne geophysical survey and a drilling survey of total 12 holes. The survey concluded as follows and is discussed in details below.

1. Four drill holes were sunk targeting the aeromagnetic anomalies of Phase I for massive sulphide ore pipes of Tsumeb/Kombat type. One hole of which; MJNM-1 intersected low grade lead and zinc mineralisation in the form of dissemination and network.

The mineralisation showed average grade of 0.23% lead and 0.38% zinc over 9.16m. Within 9.16 metre, the mineralised portions showing more than 1 percent concentration, are as follows.

111.58m-111.69m(0.11m)	Pb=1.45%	
112.30m-112.62m(0.32m)	Pb=4.52%	Zn=1.58%
245.75m-246.25m(0.50m)		Zn=1.76%
246.25m-246.65m(0.40m)		Zn=2.28%

Whereas, eight drill holes were sunk targeting the airborne electromagnetic anomalies of Phase II. One hole, MJNM-9, intersected low grade lead and zinc mineralisation in the form of disseminations and veinlets. The hole is located 700 metres northwest of MJNM-1 of Phase II. The mineral occurrence and host stratigraphic horizon may suggest that the mineralisation is an extension of that of MJNM-1 and it is subject to stratigraphic control.

Within a total of 5.24 metre intersection, the mineralised portions assaying more than 0.1 percent, are as follows;

234.10m-234.50m(0.40m)		Zn=0.58%
242.60m-243.35m(0.75m)	Pb=0.17%	Zn=0.83%
248.10m-248.64m(0.54m)		Zn=0.31%

2. In the hole MJNM-11, some dots of chalcopyrite and galena were recognized. These are associated with an intensely fractured zone within the upper Tsumeb subgroup. Chemical assays indicated a considerable concentration of Cu, Pb and Zn.

The mineralised portions assaying more than 0.1 percent, are as follows.

270.70m-270.75m(0.05m)	Pb=0.18% (Cu=0.028% Zn=0.026%)
272.30m-272.50m(0.20m)	Pb=0.10% (Cu=0.026% Zn=0.08%)

The metal ratios of Cu, Pb and Zn show the mineralisation is of Tsumeb/Kombat type. This mineral showing could be derived from an potential ore deposit of moderate size and should therefore be explored in the future.

3. Pyrite mineralisation is commonly hosted in the sandstone of Mulden group but almost no copper content was assayed in the mineralisation. The copper content and syndepositional occurrence may explain that the pyrite was biogenic and was precipitated under a reducing environment. The pyrite mineralisation is believed to be the potential source of the low resistivity anomalies present at every frequency.

4. The interpretation of airborne electromagnetic anomalies with correlation to the result of drilling indicated that the Damara system and its subsurface structure extends throughout the area covered by calcrete. However, the drilling result showed inconsistency with the exploration rationale. The low resistivity lineaments traversing the geological trend were correlated to a swarm of dolerite dykes and their associated hydrothermal alteration zones. The observed resistivity values of core samples also supported the phenomenon. None of the spot anomalies coincided with Karst or solution breccias.

5. No sandstone of Mulden group was intersected in the area where it had been expected to occur as indicated by the previous maps and the current geophysical survey. A detailed investigation of the resistivity of the surface formation is thus essential for the interpretation of the deeper structure of geology.

6. The drill depth of 300 meters are believed to be adequate for correlation between the key depth of the resistivity profiles.

Chapter 2 Recommendation of the future

Based upon the result of the survey and subsequent discussion and interpretation of all the data available, the following recommendation are made.

1. Airborne geophysical survey over the known ore deposits

The exploration rationale used in this project had been based upon the assumption that pipe like massive sulphide ore deposit should give a signal of a low resistivity anomaly and therefore these should be target of the drilling. Nevertheless, there seems to be an opposite effect that ground electromagnetic survey showed inconsistency of the ore deposit with low resistivity anomaly as seen at Khusib Springs. Therefore there is a need to restudy the geophysical response of the ore deposits themselves and ore controls. It is thus important to fly over the known ore deposit to collect the signature of ore control.

2. Restudy of exploration rationale

The exploration rationale used in this project should be thereby modified on the basis of the geophysical interpretation.

3. Ground geophysical survey and subsequent drilling

With the revised exploration rationale a detailed ground electromagnetic survey is recommended within the extracted area. The core samples of this project are available for interpretation of anomaly maps, and in particular the cores may provide more information of geophysical properties of the surface formation.

4. Follow-up exploration for MJNM-11 mineral showing

The minute mineralisation is recommended to be assessed using new exploration rationale and the result of ground geophysical survey and thereafter be drilled. In this case isotopic analysis of C14 and O18 of calcite and dolomite would be useful for delineate potential areas.

5. Exploration of a new area

For a new area to be explored, the broad area extending north of Tschudi ore deposit through northwest of Tsumeb mine is recommended. The area has no outcrop with thin calcrete being less than 100 metres thick.

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