D-4-4: Concentration of A and B rank cells in the area of Cretaceous ultramafic rocks at the eastern slope of the southwestern peninsula.

D-4-5: Concentration of A and B rank cells in the area of the Miocene Central Highland Volcanics at the northern part of Panaon Is..

(E) Factor No. 5 (Closely related to Cu)

D-5-1: Concentration of A, B and C rank cells in the area of the Quaternary Volcanics at the north and south part of Biliran Is..

D-5-2: Concentration of A, B and C rank cells in the area of Miocene volcanics at the east side of Villaba in the northwest coast.

D-5-3: Concentration of A and B rank cells in the area of Cretaceous ultramafic rocks at the northwestern side of Tacloban.

D-5-4: Concentration of A, B and C rank cells in the area of the Miocene pyroclastics 20 km NNE of Ormoc.

D-5-5: Concentration of A and B rank cells in the area of the Miocene Central Highland Volcanics 8 km north of Sogod.

D-5-6: Concentration of A and B rank cells in the area of Miocene sedimentary rocks 6 km north of Massin.

D-5-7: Concentration of A and B rank cells in the area of the Miocene Central Highland Volcanics at the northeast coast of Panaon Is..

3-5-2 Factor Analyses of Cell Average Data of Dinagat-Siargao

Factor analyses was carried out on the data using the Varimax rotation method and diagonal factor; 1.

3-5-2-1 Extraction of factors

Correlation matrix and eigenvalues (λ) taken from normalization and interpretation of the cell averages for elements are shown in Table-36 and Table-37.

Table-36 Correlation Matrix

	Cu	Pb	Zn	Ag	As	Mn	Ni	Co	Hg	Cr
Cu	1.000									
Pb	0.289	1.000								
Zn	0.448	-0.076	1.000							
Ag	0.121	0.279	0.016	1.000						
As	0.342	0.540	0.206	0.262	1.000					
Mn	-0.110	-0.361	0.533	-0.092	-0.107	1.000				
Ni	-0.417	-0.416	0.141	-0.092	-0.167	0.771	1.000			
Co	-0.304	-0.426	0.342	-0.084	-0.135	0.884	0.956	1.000		
Hg	0.239	0.294	0.388	0.137	0.494	0.428	0.355	0.424	1.000	
Cr	-0.267	-0.280	0.242	-0.063	-0.008	0.736	0.916	0.893	0.475	1.000

Table-37 Eigenvalues and Cumulative proportion of Variance

	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7
Eigenvalue l(λ) Diagonal Factor: 1	4.210	2.426	1.239	0.829	0.412	0.372	0.264
Cumulative Proportion of Variance	0.421	0.664	0.788	0.870	0.912	0.949	0.975

It can be seen from Table-37 that the eigenvalues in decreasing order are $\lambda_1=4.210$, $\lambda_2=2.423$ - - - and if those over 1 are taken, 3 factors will be considered. However, as λ_4 and λ_5 are relatively large and the cumulative proportion of total variance reaches 91 percent up to λ_5, 5 factors are adopted.

3-5-2-2 Interpretation of each factor

Adopting the five factors and diagonal factor; 1 and the left half of Table-38 shows the factor loadings which were processed by the main analysis. The right half of Table-38 shows the factor loadings after adopting the Varimax rotation method.

Interpretation of each factor are as follows.

Table-38 Factor Loadings

Before Rotation						After Rotation					
Factor	No. 1	No. 2	No. 3	No. 4	No. 5	Factor	No. 1	No. 2	No. 3	No. 4	No. 5
Cu	-0.302	0.640	0.548	0.070	-0.203	Cu	-0.310	-0.298	0.811	-0.042	0.050
Pb	-0.469	0.602	-0.386	-0.215	-0.302	Pb	-0.323	-0.812	-0.001	-0.158	0.281
Zn	0.377	0.547	0.627	0.161	0.133	Zn	0.313	0.138	0.855	-0.007	0.175
Ag	-0.141	0.387	-0.423	0.806	-0.008	Ag	-0.041	-0.114	0.030	-0.986	0.105
As	-0.153	0.788	-0.256	-0.209	0.478	As	-0.066	-0.304	0.169	-0.125	0.917
Mn	0.902	0.138	0.185	0.080	-0.054	Mn	0.872	0.126	0.305	0.038	-0.076
Ni	0.948	-0.103	-0.216	-0.011	-0.024	Ni	0.957	0.103	-0.166	0.029	-0.059
Co	0.985	0.010	-0.054	0.037	-0.012	Co	0.976	0.132	0.037	0.023	-0.045
Hg	0.441	0.739	-0.169	-0.213	-0.173	Hg	0.540	-0.580	0.300	-0.036	0.354
Cr	0.914	0.090	-0.202	-0.069	-0.025	Cr	0.939	-0.022	-0.056	0.033	0.059

(a) Factor No. 1

Factor loadings before rotation show negative values for Cu, Pb, Ag and As and positive large values for Mn, Ni, Co and Cr. These values after rotation exhibit similar tendencies as well. This factor seems to indicate concentration of Mn, Ni, Co and Cr in host rocks.

(b) Factor No. 2

Factor loadings before rotation show positive values on all elements except for Arsenic, Ni, Hg, Cu, Pb, and Zn show large positive values. After rotation, Cu, Pb, Ag, As, Hg and Cr show negative values, with Pb and Hg exhibiting large negative values. This factor seems to be related Pb vein type mineralizations.

(c) Factor No. 3

Factor loadings before rotation show positive values for Cu, Zn and Mn with Cu and Zn registering high values. After rotation Cu, Pb, Zn, Ag, As, Mn, Co and Hg show positive values with Cu and Zn exhibiting especially high values. This factor seems to indicate Cu and Zn mineralization.

(d) Factor No. 4

Factor loadings before rotation show positive values for Cu, Zn, Ag, Mn and Co with Ag showing a specially high value. Negative values on Cu, Pb, Zn, Ag, As and Hg with Ag showing a large negative value were registered after rotation. This factor seems to be related to Ag mineralization.

(e) Factor No. 5

Factor loadings before rotation show positive values for Zn and As with especially high values for As. These values after rotation show positive values for Cu, Pb, Zn, Ag, As, Hg and Cr with As registering again a high value. This factor seems to indicate hydrothermal mineralization.

3-5-2-3 Classification of factor scores

Factor scores were calculated by multiplying the cell average values by the factor score coefficient. After the statistical procedure was done, these factor scores were classified into eight ranks in the same manner done to that of the Leyte data and were plotted on a 1 : 1,000,000 scale map (Attached Pl 2-4 Nos. 1 - 5)

3-5-2-4 Distribution of the geochemical anomalies (Factor Scores)

Figure 14 and the attached plates 2-4 Nos. 1 - 5 show the areal distribution of the factor scores. The areas of concentration of the high scores are as follows.

(A) Factor No. 1 (Closely related to Mn, Ni, Co and Cr)

D-1-1: Concentration of A and B rank cells in the area of Cretaceous ultramafic rocks at the vicinity of Mt. Redondo in the northern part of Dinagat Is.

D-1-2: Concentration of A and B rank cells in the area of Cretaceous ultramafic rocks north of Libjo.

D-1-3: Concentration of A, B and C rank cells in the area of Cretaceous ultramafic rocks at the mouth of San Jose River in the eastern coast of Dinagat Is.

D-1-4: Concentration of A and C rank cells in the area of Cretaceous ultramafic rocks at the vicinity of Mt. Gaboc in the southern part of Dinagat Is.

D-1-5: Concentration of A and B rank cells in the area of Cretaceous ultramafic rocks at the northern part of Bucas Grande Is.

(B) Factor No. 2 (Closely related to Cu, Pb, Zn, As and Hg)

D-2-1: Concentration of A, B and C rank cells in the area of Cretaceous ultramafic rocks at the mouth of San Jose River in the eastern coast of Dinagat Is.

D-2-2: Concentration of A, B and C rank cells in the area of Cretaceous ultramafic rocks at the vicinity of Mt. Gaboc in the southern part of Dinagat Is.

D-2-3: Concentration of A and B rank cells in the area of the Cretaceous Sapao Formation at the northern and middle part of Siargao Is.

(C) Factor No. 3 (Closely related to Cu and Zn)

D-3-1: Concentration of A, B and C rank cells in the area of Cretaceous ultramafic rocks at the vicinity of Mt. Gaboc in the southern part of Dinagat Is.

D-3-2: Concentration of A, B and C rank cells in the area of Cretaceous Sapao Formation at the northern and middle part of Siargao Is.

D-3-3: Concentration of A and B rank cells in the area of Cretaceous ultramafic rocks at the northern part of Bucas Grande Is.

D-3-4: Concentration of B and C rank cells in the area of Miocene andesite at the northern part of Masapelid Is.

(D) Factor No. 4 (Closely related to Ag)

D-4-1: Concentration of A, B and C rank cells in the area of Cretaceous ultramafic rocks at the north side of Libjo.

D-4-2: Concentration of A, B and C rank cells in the area of Cretaceous ultramafic rocks at the mouth of San Jose River in the eastern coast of Dinagat Is.

D-4-3: Concentration of A, B and C rank cells in the area of Cretaceous ultramafic rocks at the northern part of Bucas Grande Is.

D-4-5: Concentration of A rank cells in the area of Miocene andesite at the northern part of Masapelid Is.

(E) Factor No. 5 (Closely related to As and Hg)

D-5-1: Concentration of A, B and C rank cells in the area of Cretaceous ultramafic rocks north of Libjo .

D-5-2: Concentration of A, B and C rank cells in the area of Cretaceous ultramafic rocks along the vicinity of the mouth of San Jose River in the eastern coast of Dinagat Is.

D-5-3: Concentration of A, B and C rank cells in the area of the Cretaceous Sapao Formation at the northern and middle part of Siargao Is.

D-5-4: Concentration of A, B and C rank cells in the area of Cretaceous ultramafic rocks at the northern part of Bucas Grande Is.

D-5-5: Concentration of A rank cells in the area of Miocene andesite at the northern part of Masapelid Is.

3-6 Univariate Analyses of Analytical Results of Panned Samples (Attached P1.-3)

A total of 222 panned samples were collected from Leyte and 118 samples from Dinagat-Siargao. Gold (ppb), Ag (ppb) and Ga (ppm) were analyzed by AAS method at the PETROLAB. Univariate analyses of these results were carried out.

Samples having values below the detection limits were assigned values corresponding to 1/2 of the detection limit values of the concerned elements.

3-6-1 Univariate Analysis of Analytical Results of Panned Samples of Leyte

Analytical values above M+1.0σ were classified into three ranks and were plotted on a 1 : 1,000,000 scale map with the corresponding rank symbols (attached P1. - 3).

Table-39 Basic Statistical Values of the Analytical Results of Panned Samples of Leyte

	Au (ppb)	Ag (ppb	Ga (ppm)
M	245	221	15.6
M+1.0σ	2035	1437	20.9
M+1.5σ	5865	3664	24.2
M+2.0σ	16903	9344	28.0
Maximum	22800	11700	31.3
Minimum	5	50	2.0
Detection Limit	20	100	4.0

Classified Symbol

Rank	Classified Range	Symbols		
		Au	Ag	Ga
A	M+2.0σ ≦ Z	◎	◬	▣
B	M+1.5σ ≦ Z < M+2.0σ	○	△	□
C	M+1.0σ ≦ Z < M+1.5σ	○	▵	▫

As presented in P1.-3, the anomalous cells of each element are concentrated as follows.

Au: Three B rank cells and one each of A, B and C rank cells occur at the northern to the southeastern part of Panaon Is..

Ag: Two A and one B rank cells occur at northern Panaon while one B and two C rank cells occur at southeastern Panaon Is.

Ga: Anomalous cells scatter all over Leyte, but one A and two C rank cells are found at the west side of the Philippine Fault in Southern Leyte.

3-6-2 Univariate Analyses of Analytical Results of Panned Samples of Dinagat-Siargao

As mentioned in 3-6-1, anomalous values over M+1.0σ values were classified into three ranks in the same manner as the Leyte data and were plotted on a 1 : 1,000,000 scale map with the corresponding symbols.

Table-40 Basic Statistical Values of the Analytical Results of Panned Samples of Dinagat-Siargao

	Au (ppb)	Ag (ppb)	Ga (ppm)
M	74.7	66.2	2.4
M+1.0σ	510.3	164.1	6.9
M+1.5σ	1,333.8	258.4	11.7
M+2.0σ	3,486.0	406.8	19.8
Maximum	5,000	1,100	15
Minimum	5	50	1
Detection limit	10	100	2

As presented in P1.-3, the anomalous cells of each element are concentrated as follows.

Au: Two C and A rank cells occur in peridotite area at the southern part of Dinagat Is. and numerous anomalous cells occur in the north and middle part of Masapelid Is.

Ag: Several anomalous cells occur in peridotite area at the southern part of Dinagat Is. and in the northern and middle part of Masapelid Is.

Ga: Four A, four B and two C rank cells occur at the area of Cretaceous tuff and andesite in the northern part of Siargao Is.

3-7 Modal Analyses of Panned Samples

Thirty samples from Leyte and ten samples from Dinagat-Siargao where selected at random from the panned samples. Identification of the constituent minerals were carried out at the PETROLAB with binocular microscope.

The samples collected from areas having scarce heavy minerals contained considerable amount of silicate minerals, as the panning activities were undertaken with unified procedure in each hinterland (Attached P1.4-2).

3-7-1 Characteristics of the Ratios of Constituent Minerals in the Identified Panned Samples

Identified heavy mineral samples in Leyte are classified into four groups on the basis of the ratio of the constituent heavy minerals, and the groupings seem to reflect the different source lithology.

Table-41 Ratio of Constituent Minerals of Panned Samples

Mineral	Magnetite	Chromite	Ilmenite	Rutile	Fe Minerals	Zircon	Olivine	Pyroxene	Amphibole	Feldspar	Quartz	Others	Total
Code	mt	cm	il	ru	Fe	Z	ol	P	H	F	Q	OTH	
Leyte	41.6%	2.5%	3.15%	0.15%	9.75%	0.1%	1.7%	6.0%	13.5%	4.3%	7.7%	9.55%	100%
Dinagat-Siargao	45.5%	23.5%			18.0%		2.0		2.5%	6.5%	1.5%	0.5%	100%

Table-42 Relationship between Geochemical Anomalies and Surveyed Mineral Showings

Area	No.	Mineral Showing	Commodity	Cell Average										High-Pass Filter										Factor Analysis				
				Cu	Pb	Zn	As	Mn	Ni	Co	Mo	Hg	Cr	Cu	Pb	Zn	As	Mn	Ni	Co	Mo	Hg	Cr	No. 1	No. 2	No. 3	No. 4	No. 5
																								Post	Post	Post	Post	Post
Leyte	16	Mt. Bagacay	Cu						◎	○			-	◎	○					◎	○	○	-				◎	
	17	Maasin	Ni	◎			○		○				-	○					○			○	-		◎			
	22	Ingan	Au, Ag			◎				○			-	○						○	○		-	○			◎	◎
	23	Sogod	Cu	◎	◎	◎	○	○		○	○		-	◎	○	○	○	○	○	○		○	-	◎	◎	◎		◎
	25	Bagacay	Cu	◎									-	○					○				-		◎		◎	◎
	30	Pansagan	Mn										-							○			-					
	33	Biliran	Native Sulpher	○			○					○	-				○	○				○	-		◎	◎		○
	40	Pulta	Au, Ag	○			○						-										-			○	○	◎
	41	Curajo	Cu	◎					○	○			-	○		○				○			-	○	◎		◎	◎
	46	Antipolo	Ni			○							-										-		○	○		
	48	Caibaan	Cu	◎				○	○	○			-	○		○							-	◎	◎		◎	◎
	50	Suhi	Cu						○				-	○									-	◎	◎	◎	◎	◎
	51	Pinut-an	Au	◎	◎	◎	◎				◎	◎	-	◎	◎	◎	◎		◎		○	◎	-		◎	◎	○	○
	52	Anilao	Cu	◎	◎	○	◎		◎	○		◎	-	◎	◎	○	◎		◎	◎		◎	-		◎	○	◎	◎
Dinagat-Siargao	①	Talisay	Cr	○		○		◎	◎	◎	-	○	○								-			◎		◎		
	②	Masdang	Cr						○		-										-			○	◎			◎
	⑤	Velore	Cr								-			○				○			-			◎	◎	○		
	⑬	Redondo	Cr					◎		◎	-										-					○		
	⑭	Tagbaboy (1)	Cr				○				-	◎								○	-							
	⑮	Cangumod	Au	◎	◎	○	◎				-	◎		○			◎				-	○		●		◎	◎	◎
	⑯	Avelina	Cr								-	◎									-				○		◎	

◎ : Mineral showing with an overlapping M + 1.5 σ anomaly
○ : Mineral showing with an overlapping M + 1.0 σ anomaly
● : Mineral showing with an overlapping negative anomaly on factor analysis

Post ; After rotation
Pre ; Before rotation

(1) The group showing over 80 percent heavy mineral ratios (9 samples)
This group mainly occurs in the eastern slope of the Central Highland Volcanics which is traversed by the Philippine Fault (one sample occurs in the western slope). The main heavy mineral is magnetite (over 50 percent) probably coming from the volcanic rocks of the source area.

(2) The group showing 60-80 percent heavy mineral ratios (11 samples)
This group occurs at the western side of group 1, and in the Quaternary volcanics. The main heavy mineral is magnetite (over 70 percent) reflecting the influence of the volcanic rocks of the source.

(3) The group showing 30-60 percent heavy mineral ratios (8 samples)
This group mainly occurs in Tertiary sedimentary rocks in northwestern Leyte.

(4) The group showing below 20 percent heavy mineral ratios (2 samples)
One sample each occurs at the northwestern and northeastern coast. The low heavy mineral ratio seems to have been affected by the scarce heavy minerals of the source.

3-7-2 Characteristics of the Constituent Minerals of Panned Samples of Dinagat-Siargao

The majority of panned samples of Dinagat-Siargao have heavy mineral ratios over 80 percent.
These occur in ultramafic rock areas in the northern to the central part of Dinagat Is., in the northern part of Siargao Is. (6 samples), and in the Miocene Masapelid Formation and Mabuhay Andesite in Masapelid Is. (3 samples). The northern

to central Dinagat samples contain abundant chromite while northern Siargao Is. samples are rich in magnetite. The Masapelid Is. samples contain abundant Fe-minerals. Masapelid Fe minerals are probably derived from hydrothermal alteration products.

One sample however have heavy mineral ratio of 70 percent. This sample occurs in alluvium sediments at the vicinity of Libjo in the western coast of Dinagat Is. The low content of heavy minerals seems to be due to the scarce amount of heavy minerals in the background.

4. Correlation with Existing Regional Data

During data collection in the fiscal year 1984, compilation of existing gravimetric and aeromagnetic survey maps and extraction of lineaments from LANDSAT Images were carried out. These data, as presented in this report, were plotted on a 1 :1,000,000 scale map (Attached P1, 5, 6, 7) and were analyzed in terms of their significance and relationship with the results of the geological and structural surveys.

4-1 Gravity Data

Gravimetric data are available only for the northern and southwestern parts of Leyte. A bouguer anomaly map (Attached P1.-5) was drawn with 10 milligal contour interval.

From the above mentioned map, it is clear that the gravimetric contours show parallel trend to the Philippine Fault. High Bouguer anomalies (over 100 mGal) are observed at the northeastern and southwestern parts where exposed Cretaceous ophiolite and pre-Cretaceous metamorphic rocks are observed. One Hundred (100) to 50 milligal medium anomalies are observed in the Central Highland Volcanics along the Philippine Fault and 100 to 60 mGal anomalies are observed west of the Tertiary sedimentary rock anticline axis near Ormoc.

4-2 Aeromagnetic Data

Aeromagnetic data is only available for Leyte and a total magnetic intensity map (Attached P1.-6) was drawn.

This map shows that the contour lines exhibit a general trend of ENE to WSW similar to what has been observed in Bohol Is. Local high anomalies accompany low anomalies at the central part. These local anomalies are intermittently associated with the Quaternary volcanic rocks. These local low anomalies seem to indicate the presence of a geothermal zone in the Quaternary volcanoes.

4-3 Lineament Data

Plate-7 combined two lineament plates compiled from LANDSAT image analyses made by JICA-MMAJ and NRMC (Natural Resources Management Center) of the Philippines. The former analyzed the LANDSAT images during the first fiscal year while the latter analyzed the images combining the various available data of Leyte and Dinagat-Siargao. The lineament map shows that the Philippine Fault, the N-S trending anticline axes in the Tertiary sedimentary rocks west of Ormoc, the NW-SE structures in pre-Tertiary rocks of the northeastern part and the NNW-SSE anticline axis in the pre-Tertiary rocks of the southwestern peninsula controlled the structures in Leyte. As for the Dinagat-Siargao area, NW-SE trending main faults controlled the distribution of the various formations while NE-SW and E-W trending lineaments seem to reflect the oblique faults present.

5. Relationship between Geochemical Anomalies and Mineral Showings

The mineral showings surveyed in Leyte and Dinagat-Siargao and the corresponding geochemical anomalies are shown in Table-42. Mineral showings with many univariate anomalies include Sogod (23), Bagacay (25), Curajo (41), Caibaan (48), Suhi (50), Pinut-an (51) and Anilao (52) in Leyte; Cangumod (15) in Masapelid Is.; and Avelina (16) in Dinagat Is. Mineral showings associated with numerous multivariate anomalies are Sogod (23), Bagacay (25), Curajo (41), Caibaan (48), Suhi (50), Pinut-an (51) and Anilao (52) in Leyte; Cangumod ⑮ in Masapelid Is.; and Avelina ⑯ in Dinagat Is.

From the above listing, the most significant mineral showings characterized by numerous geochemical anomalies are Curajo, Caibaan, Suhi, Sogod, Pinut-an and Anilao in Leyte and Cangumod in Masapelid Is.

Mineralization and alteration were reported at Saint Bernard in southeastern Leyte (Esguerra and Cabantog, 1989, ms.), but this area was not covered during the survey.

6. Evaluation and Conclusion

6-1 Consolidated Evaluation of The Survey Results

6-1-1 Geology and Structure

The survey area is located in the eastern side of Philippine archipelago, bounded by Luzon Is. in the northwestern side, Mindanao Is. in the south, Masbate, Cebu and Bohol Islands in the west and the Philippine Sea in the east.

According to Mitchel's model (1986), the Sulu-Zamboanga-Masbate arc was located in the western and southwestern Mindanao terrane. This drifted from the southern part due to the collision event which resulted in the displacement of the eastern terrane in a northwest direction for a considerable distance.

The influence of the above mentioned structural setting is reflected on the distribution of the geological structures in the area. *As an example, the pre-Cretaceous Lawagan Metadiorite in* Southwestern Leyte is believed to be a remnant of the Sulu-Zamboanga-Masbate Arc uplifted terrane. The Miocene formations deposited in Northwestern Leyte containing volcanic lastic sequences are interpreted as backarc basin sediments, the deposition of which are believed to be related to the subduction along the Philippine trench and consequent volcanism. Ophiolite slabs thrusted over the pre-Cretaceous formation observed in northeastern and southwestern Leyte, Dinagat and Siargao Islands are similar to those of Bohol.

Along the Philippine Fault which run through Leyte, the Miocene Central Highland Volcanics and Quaternary Volcanics were erupted. The Central Highland Volcanics in Panaon Is. are found to contain Au and Ag mineralization.

The oldest formation of this area are the Jurassic Babatngon Metamorphics in Northeastern Leyte and the Jurassic Lawagan Metadiorite in Southwestern Leyte. Cretaceous ophiolites which consist of peridotite, gabbro, diabase, basalt and chert are thrusted over the above mentioned metamorphic rocks. Similarly to the Cretaceous ophiolite in Dinagat Is. is overthrusted on the Nueva Estrella Amphibolite. This is assumed to be the oldest formation in this island.

During the Paleocene, the Amontay Sandstone and Salug Volcanics were deposited and extruded respectively in Leyte.

During the Eocene, the Gilonon Formation which is composed of pyroclastic rocks in Southwestern Leyte and the Loreto Clastics in Dinagat Is. were deposited. The Hindang Diorite was intruded in Southwestern Leyte.

In the Oligocene, the Albuera Diorite intruded the central highlands of Leyte while the Bacuag Formation which is composed of basaltic pyroclastic rocks, were formed in Masapelid Is.

The Miocene time is characterized by limestone deposition in Northwest and Southwest Leyte and Masapelid Is. In addition to that, sandstone, shale and conglomerate were also deposited. The Central Highland Volcanics were erupted during the Early Miocene in Leyte. Pyroclastic rocks were also formed and deposited in various places from Late Miocene to Pliocene.

During the Pliocene, limestones were deposited in Dinagat and Siargao Islands while pillow basalts were erupted in Northwestern Leyte.

During Quaternary, coral reefs were formed in various places and the andesitic lavas were erupted in central highland of Leyte and Biliran Islands.

6-1-2 Mineralization

Mineralization observed in the study area are as follows: (Examples are shown in Brackets)

(1) Massive sulphide type mineralization

This type of mineralization is observed in Cretaceous ophiolite in northeastern Leyte. The host rocks are the pillow basalts and pelagic sediments of the ophiolite (25. Bagacay, 41. Curajo 48. Caibaan).

(2) Hydrothermal vein type mineralization

This type of mineralization is mainly observed as fissure filling in the Miocene Central Highland Volcanics of Leyte and Miocene Mabuhay Andesite of Masapelid Is. Veinlets and disseminations in breccia matrix usually accompany this type of mineralizations. Epithermal gold veins associated with gravity faults in graben zone are important (16. Mt. Bagacay, 22. Ingan, 23. Sogod, 40. Pulta, 46. Antipolo, 50. Suhi, 51. Pinut-an, ⑮ Cangumod). An exceptional example, nickeliferous vein formed by nickel enriched solution is observed. The nickel is assumed to have been extracted from the host rock. (52. Anilao).

(3) Residual type concentration

This type is observed as nickel laterites derived from the weathered serpentinite and manganese nodules in pyroclastic rocks. (17. Maasin, 30. Pangasgan).

(4) Orthomagmatic mineralization

This type of mineralization is formed as chromite concentration during magmatic differentiation of the ultramafic rocks. Chromite is usually associated with dunite. Layered type is exposed at the northern Dinagat Is. while podiform type occurs at the central to the southern part of Dinagat Is. (① Talisay, ② Masdang, ⑬ Redondo, ⑭ Tagbaboy ⑯ Avelina)

6-1-3 Synthesis and Interpretation of the Results of Geochemical Analyses

For the purpose of synthesis and interpretation of the results of the geochemical data, analytical values of each cell were statistically processed by the following four methods:

(1) Univariate analyses of the average values of the chemical data in each cell (Cell average value).

(2) Univariate analyses of the moving average data, where a frame consisting of nine cells (three cells in both N-S and E-W direction) is set and the average value of the nine cells is taken to be the value of the central cell. The frame is moved one cell at a time throughout the survey area.

(3) Univariate analyses of the high-pass filter data which are the positive differences between the cell average values and the corresponding moving average valves.

(4) Multivariate analyses (factor analyses) of the cell average values.

Anomalous cells were extracted from the above analyses using the following standard:

(A) Each anomalous zone should be defined by the anomalous values of at least two elements.

(B) Each anomalous zone should at least be suggested by more than two methods of geochemical analyses.

(C) In addition to satisfying the above two conditions, alteration associated with mineralization should also be observed in the anomalous zone.

Table-43 and Attached P1.-9 show the anomalous zones selected on the basis of these standards and the relevant features of each anomalous zone.

The evaluation of these anomalous zones are as follows: First of all, it should be noted that the Samar area was excluded from the evaluation since the geochemical sample density is low compared with those of Leyte and Dinagat-Siargao areas. Furthermore, geological survey in the area has been suspended.

Leyte area

(1) Central-eastern part of Biliran Is.

Arsenic, Mn, Co, Mo and Hg anomalous cells defined by univariate analyses and Factor No. 2 (closely related to hydrothermal alteration) and Factor No. 5 (closely related to Cu) overlap.

This zone is characterized by native sulphur mineral showings derived from the fumaroles of Quaternary volcanics. This zone, however, is not selected as a promising zone, because most of the native sulphur has been mined out. The possibility of epithermal Au-mineralization however is not discounted.

(2) Northwest part of Tacloban

Anomalous cells of Cu, Zn, Ni and Co of the univariate analyses overlap with anomalies for Factors 2, 4 and 5 (closely related to hydrothermal alteration). This zone is associated with massive sulphide mineral showings (Curajo, etc.) and vein type mineral showings (Suhi, etc.) in Cretaceous ophiolite (Promising zone III).

Table-43 Anomalous Elements of each Anomalous Zones and Geological Setting

Area	No.	Location	Cell Average										High-pass Filter										Factor Analysis					Geological Setting
			Cu	Pb	Zn	As	Mn	Ni	Co	Mo	Hg	Cr	Cu	Pb	Zn	As	Mn	Ni	Co	Mo	Hg	Cr	I	II	III	IV	V	
Leyte	1	Middle eastern part of Biliran Is. (A-1) 124°31'E 11°19'N				○					○	-				○	○		○	○	○	-		○			○	This anomalous zone occurs in Quarternary volcanics. Accompanied with native sulphur mineral showing (Biliran).
	2	Northwest side of Tacloban (A-3) 124°58'E 11°11'N	○		○				○			-	○		○			○	○			-		●		○	○	This anomalous zone occurs in Cretaceous ophiolite. Accompanied with massive sulfide mineral showing (Curajo).
	3	24 km southwest side of Tacloban (A-4) 124°46'E 11°06'N			○		○		○			-					○		○			-	○	○				This anomalous zone occurs in Central Highland Volcanics. Accompanied with sulfide vein type mineral showing (Antipolo).
	4	8 km north of Sogod (A-6) 124°58'E 10°25'N	○	○	○	○	○					-	○	○	○	○	○	○	○		○	-	○	○	○		○	This anomalous zone occurs in Central Highland Vlcanics. Accompanied with sulfide vein type mineral showing (Sogod).
	5	Northeast coast of Panaon Is. (A-8) 125°13'E 10°09'N	○	○	○	○		○	○		○	-	○	○	○	○		○	○			-	○	○	○	○	○	This anomalous zone occurs in Central Highland Volcanics. Accompanied with auriferous vein type mineral showing (Pinat-an).
Dinagat-Siargao	1	North side of Libjo in the westcoast (A-2) 125°35'E 10°27'N						○	○	-					○		○	○	○	-	○	○	○				○	This anomalous zone occurs in Dinagat Ophiolite. Accompanied with orthomagmatic type chromite mineral showing (Talisay).
	2	Vicinity of Mt. Gaboc in the southcoast (A-4) 125°41'E 9°51'N			○	○	○	○	○	-	○						○	○	○	-	○	○	○	○	○			This anomalous zone occurs in Dinagat Ophiolite and is the vicinity of Nonoc (Laterite type Ni-Cr deposit).
	3	Northern part of Bucas Grande Is. (A-5) 125°53'E 9°46'N	○		○	○	○	○	○	-	○				○		○	○	○	-	○	○	○		○	○	○	This anomalous zone occurs in Dinagat Ophiolite, mineral showing is not known.
	4	Northern part of Masapelid Is. (A-6) 125°39'E 9°41'N	○	○		○				-	○		○	○	○	○	○			-	○				○	○	○	This anomalous zone occurs in Miocene altered Mabuhay Andesite. Accompanied with auriferous hydrothermal vein type mineral showing (Cangumod).

○: Element or factor related anomalous zone.

●: Negative factor related anomalous zone.

(3) Southwestern part of Tacloban

Anomalous cells of Zn, Mn, Ni and Co of the univariate analyses overlap with the anomalies for Factors 1 and 2 (Closely related to hydrothermal alteration). This zone is associated with a nickeliferous vein mineral showing (Antipolo) along serpentinite dike in Miocene Central Highland Volcanics. This is not considered a promising zone because of the limited extent of the mineralization.

(4) Northern part of Sogod

Copper, Pb, Zn, As, Mn, Ni and Co anomalous cells of the univariate analyses and the anomalies for Factors 1, 2, 3, and 5 (closely related to hydrothermal alteration) overlap.
This zone is associated with vein type mineral showings (Sogod) in the Miocene central Highland Volcanics (Promising zone II).

(5) Northeastern coast of Panaon Is.

Copper, Pb, Zn, As, Ni, Co and Hg anomalous cells of the univariate analyses and all the anomalies defined in factor analysis overlap.
This zone is characterized by gold-bearing vein type mineralization (Pinut-an, etc.) in the Miocene Central Highland Volcanics (Promising zone I).

Dinagat-Siargao area

(1) Northern part of Libjo in the west coast of Dinagat Is.

Zinc, Mn, Ni, Co, Hg and Cr anomalous cells of the univariate analyses and the anomalies for Factors 1 (Closely related to Mn, Ni, Co and Cr) and 5 (Closely related to hydrothermal alteration halo) overlap.
This zone is characterized by orthomagmatic type mineral showings (Talisay, etc.) in the Dinagat ophiolite. This was not selected as a promising zone since the mineral showings are limited.

(2) Vicinity of Mt. Gaboc in Southern Dinagat Is.

Zinc, As, Mn, Ni, Co, Hg and Cr anomalous cells of the univariate analyses and the anomalies for Factors 1 (Closely related to Ni, Co and Cr of the host rocks) and 2, 3 (Closely related to hydrothermal alteration) overlap. The exact type of mineral showing is not known but nickeliferous laterite concentration is expected because the location is very near Nonoc Mine (Promising zone II).

(3) Northern part of Bucas Grande Is.

Copper, Zn, As, Mn, Ni, Co, Hg and Cr anomalous cells of the univariate analyses and the anomalies for Factors 1 (Closely related to Ni, Co and Cr of the host rocks) and 3, 4 and 5 (Closely related to hydrothermal alteration) overlap. No mineral showing is known in this area but nickeliferous laterite concentration is suspected. This zone was not selected at a promising zone since the anomalies are generally weak.

(4) Northern part of Masapelid Is.

Copper, Pb, Zn, As, Mn and Hg anomalous cells of the univariate analyses and the anomalies for Factors 3, 4 and 5 (Closely related to hydrothermal alteration) overlap.
This zone is defined by gold bearing vein type mineral showing (Cangumod) in the altered Miocene Mabuhay Andesite (Promising zone I).

6-2 Conclusions

Taking all relevant data into consideration, five promising areas are selected with the following priorities:

Leyte area

(I) Northeastern coast of Panaon Is.

This area is characterized by overlapping anomalous zones of Cu, Pb, Zn, As and Hg, etc. in the Miocene Central Highland Volcanics.
Two mineral showings are known, Pinut-an at the southern part and Anilao at the northern part.
The expected mineralization is of the gold-bearing quartz vein type and the target commodities are Au and Ag.

(II) Northern part of Sogod

This area is characterized by overlapping anomalous zones of Cu, Pb, Zn, As and Hg, etc. in the Miocene Central Highland Volcanics.
Mineral showing in Sogod is known. Vein type base metal mineralization is expected and the target commodities are Cu, Pb and Zn.

(III) Northwestern part of Tacloban

This area shows overlapping anomalous zones of Zn, Mn and Co, etc. associated with the Cretaceous ophiolite.
Several mineral showings are known (Curajo, Caibaan and Suhi, etc.). Possible mineralizations includs Massive sulphide and vein type deposits and the expected commodities are Cu, Pb and Zn.

Dinagat-Siargao area

(I) Northern part of Masapelid Is.

This area is characterized by overlapping anomalous zones of Cu, Pb, Zn, As and Hg, etc. in altered Miocene Mabuhay andesite.

Mineral showing in Cangumod is known. Gold-bearing quartz vein type mineralization is expected and target commodities are Au and Ag.

(II) Vicinity of Mt. Gaboc in Southern Dinagat Is.

This area is defined by overlapping anomalous zones of Mn, Co, Ni and Cr, etc. associated with the Cretaceous ultramafic rocks. The type of mineralization is not known, but its locality is very close to Nonoc Mine. Nickeliferous laterite concentration (similar to Nonoc Mine) is anticipated and the expected commodities are Ni, Cr, and Co.

References

Leyte

Abarquez, O., 1987, unpub*1. Mineral Canvassing of Western Leyte: Bureau of Mines.

Balce, G., Bondame, W., Tumanda, F., Miranda, C., 1984, unpub. Geological History of the Philippines: Bureau of Mines.

Balangue, R., Doroteo, R., Esguerra, E. and Gerardo, J., 1982, unpub., Geology of Northwest Upper Daguitan River: PNOC-EDC Geothermal Proj.

Barcelona, B., 1981, The Nature of Faults in the Philippine Fault Zone, in the Fourth Regional Conf. on Geol., Mineral and Energy Res. of SE, Manila.

Cabantog, A., Esguerra, E., 1989, ms.*2, Geology and Mineral Deposits of Leyte Island, Central Philippines.

Domingo, C. and Felizmenlo, Z., 1951, unpub., Report on the Biliran Sulphur Deposits of Biliran Island: Bureau of Mines.

Fernandez, J.C., 1970, unpub., Geological Investigation of Nickel Project, Bo. Antipolo, Jaro, Leyte: Bureau of Mines.

Garcia, M.V. and Mercado, J.M., 1981, Geology and Mineral Deposits of Samar and Leyte Islands: J. Geol. Soc. Phil.

Javellosa, R., 1980, unpub., Exploration Studies of Cu-Au Prospect on Bgy. Ingan, Hinunangan, So. Leyte: Bureau of Mines.

Javellosa, R., 1981, unpub., Notes on the Geological and Geochemistry of Cu-Au Prospect in Bgy Bantawonm St. Bernard, So. Leyte: Bureau of Mines.

JICA-MMAJ., 1986, Report on the Mineral Exploration-Mineral Deposits and Tectonics of two Contrasting Gelogic Environments in the Republic of the Philippines. Phase II Northern Leyte Area, Southern Leyte-Dinagat-Siargao Area.

Palacio, D., 1956, unpub., Preliminary Report on the Geology and Rock Asphalt Deposits of Balite, Villaba, Leyte: Bureau of Mines

Pilac, J., 1965, unpub. Geology of Northern Leyte: Bureau of Mines.

Samonte, C., 1971, unpub., Geological Investigation of the Copper Prospects in Barrio Pulta, Hilongos, Northern Leyte: Bureau of Mines.

Zepeda, Z., 1971, unpub., Memorandum Report on the Geological Investigation for the verification of the Magnetite Sand in Dulag, Northern Leyte: Bureau of Mines.

Dinagat-Siargao

Abarquez, O. E. et. al., 1980, Report on the Geology and Mineralization of Masapelid Island, Surigao Del Norte: Bureau of Mines and Geo-Sciences, Manila. p.10.

Ariate, E. et. al., 1978, Notes on the Geological Investigation of Chromite Areas Within the Surigao Mineral Reservation in Dinagat Island.

Balce, G., 1981, unpub., Ultramafics, Bureau of Mines and Geo-Sciences. p.26-27.

BMG, 1981, Geology and Mineral Resources of the Philippines, vol. I.

BMG, 1986, Geology and Mineral Resources of the Philippines, vol II.

Fernandez, H. E., 1966, The Geology of Siargao Island, Surigao Del Norte, Bureau of Mines and Geo-Sciences, Manila, 17. p.

Hawkins, J. et. al., 1985, Geology of Composite Terranes of East and Central Mindanao.

Malicdem, D. G. et. al., 1958, unpub., Preliminary Report on The Geology of Part of Dinagat Island, Surigao Del Norte: Bureau of Mines and Geo-Sciences, 68 p.

Mitchell, A. H. G. 1984, Cenozoic Evolution of The Philippine Archipelago, Internal Technical Report, UNDP-GCR/84/7 28p.

Mitchell, A. H. G., et. al., 1984, Geology of Northern Agusan, Mindanao, Internal Technical Report: UNDP-GLR/84/2. 45 P.

Santos-Yñigo, L. et. al., 1961, Geology and Geochemistry of The Nickeliferrous Laterite of Nonoc and Adjacent Islands, Philippines: Bureau of Mines. SPS. No. 18.

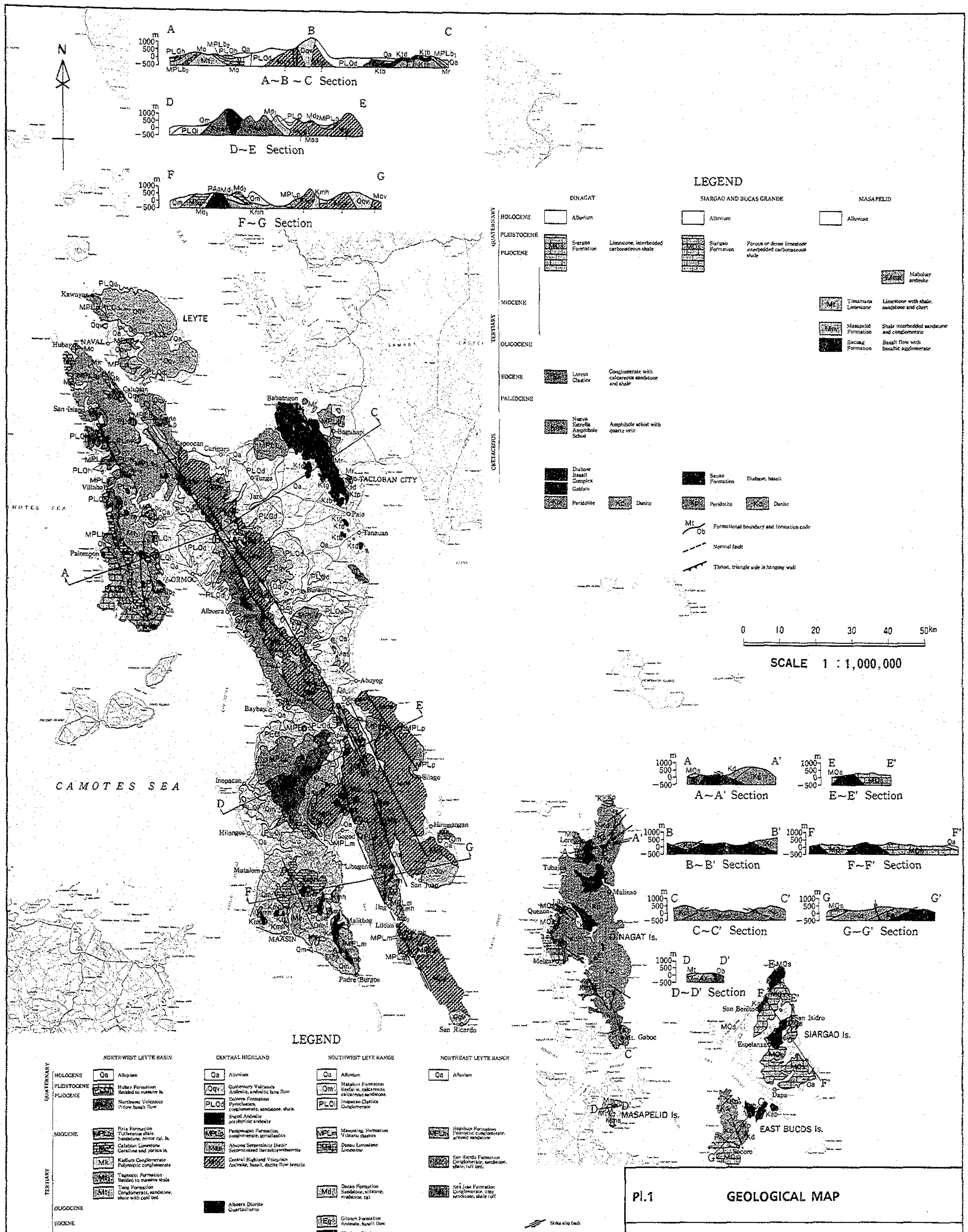
Sunga, V.M., Palaganas, U., 1986, ms, Geology and Mineral Resources of Dinagat Island Group.

Zerda, R., 1964, Aluminous Laterite Deposits of Bucas Grande Island, Surigao Mineral Reservation, Mindanao.

*1 unpub. ; unpublished

*2 ms. ; manuscript

Pl.1 Geological Map and Section (1:1,000,000)



A~B~C Section
D~E Section
F~G Section
LEGEND
DINAGAT
SIARGAO AND BUCAS GRANDE
MASAPELID
LEYTE
TACLOBAN CITY
CAMOTES SEA
SCALE 1 : 1,000,000
A~A' Section
E~E' Section
B~B' Section
F~F' Section
C~C' Section
G~G' Section
D~D' Section
DINAGAT Is.
SIARGAO Is.
MASAPELID Is.
EAST BUCDS Is.
LEGEND
NORTHWEST LEYTE BASIN
CENTRAL HIGHLAND
SOUTHWEST LEYTE RANGE
NORTHEAST LEYTE RANGE
Pl.1
GEOLOGICAL MAP
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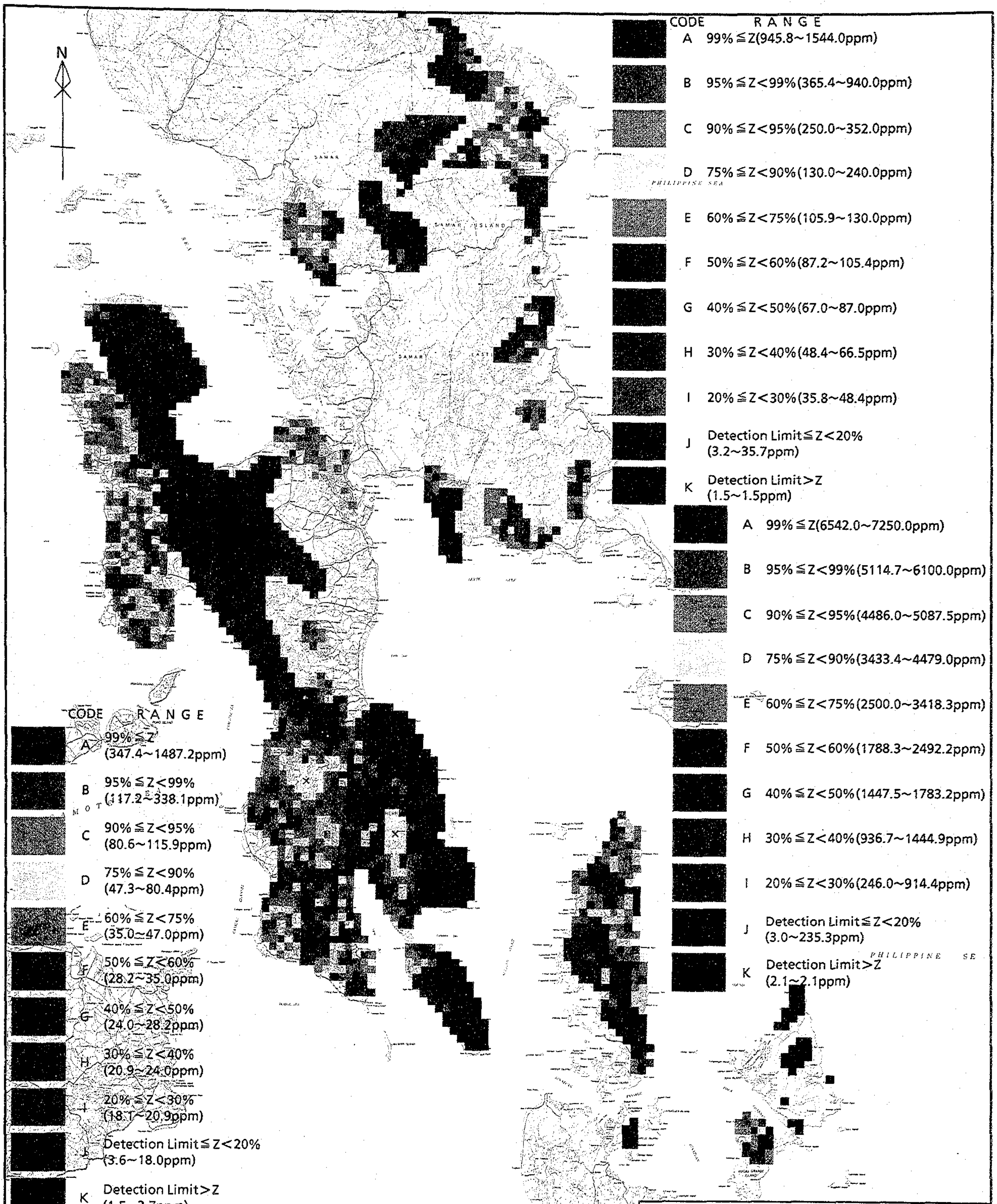
Pl.2-1 (No. 1 to No. 11) Geochemical Analysis Cell Average Values Distribution Map (1:1,000,000)



Pl.2-1-7 GEOCHEMICAL ANALYSIS CELL AVERAGE VALUES OF Ni DISTRIBUTION MAP

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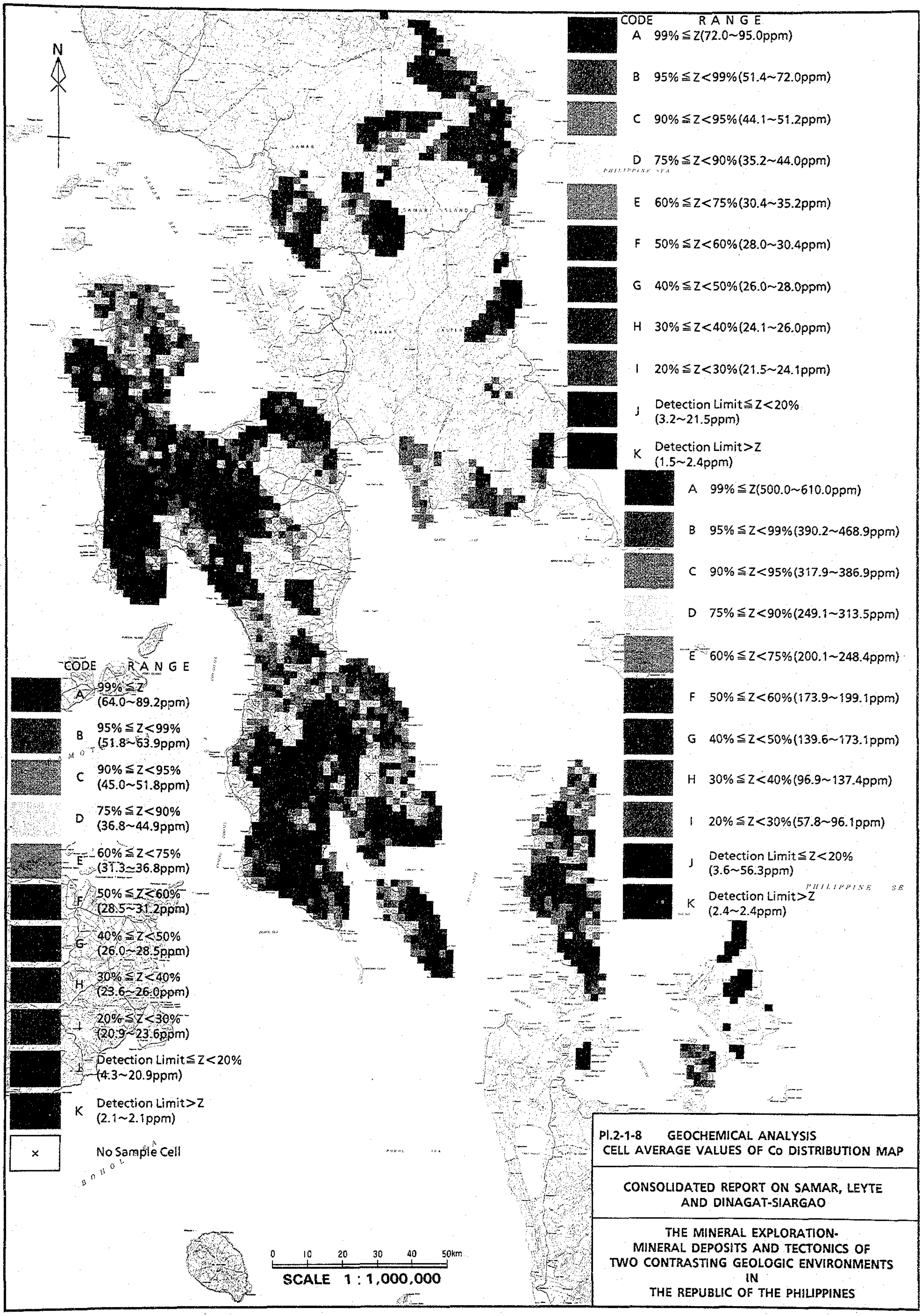

Pl.2-1-8 GEOCHEMICAL ANALYSIS
CELL AVERAGE VALUES OF Co DISTRIBUTION MAP

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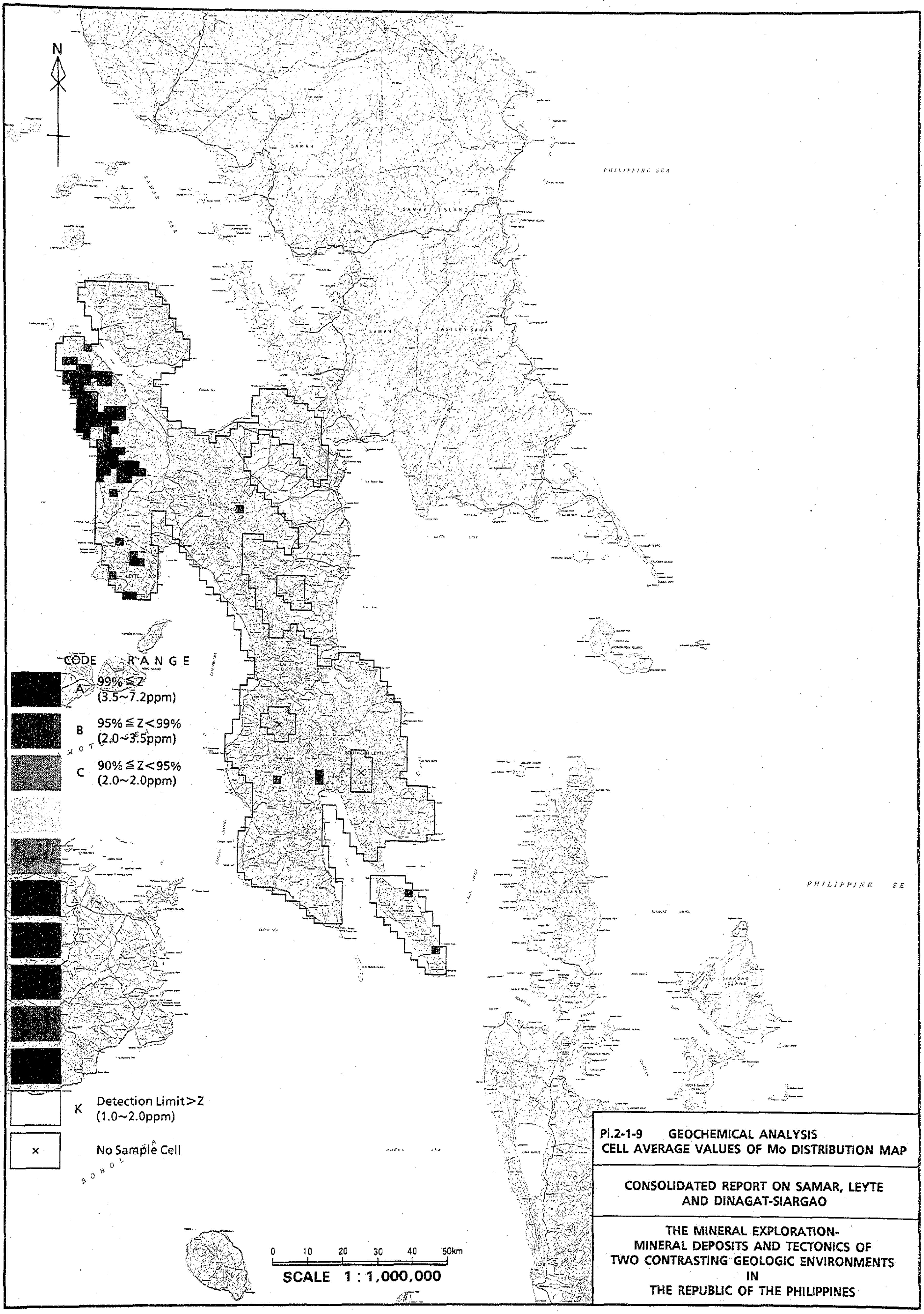

Pl.2-1-9 GEOCHEMICAL ANALYSIS
CELL AVERAGE VALUES OF Mo DISTRIBUTION MAP

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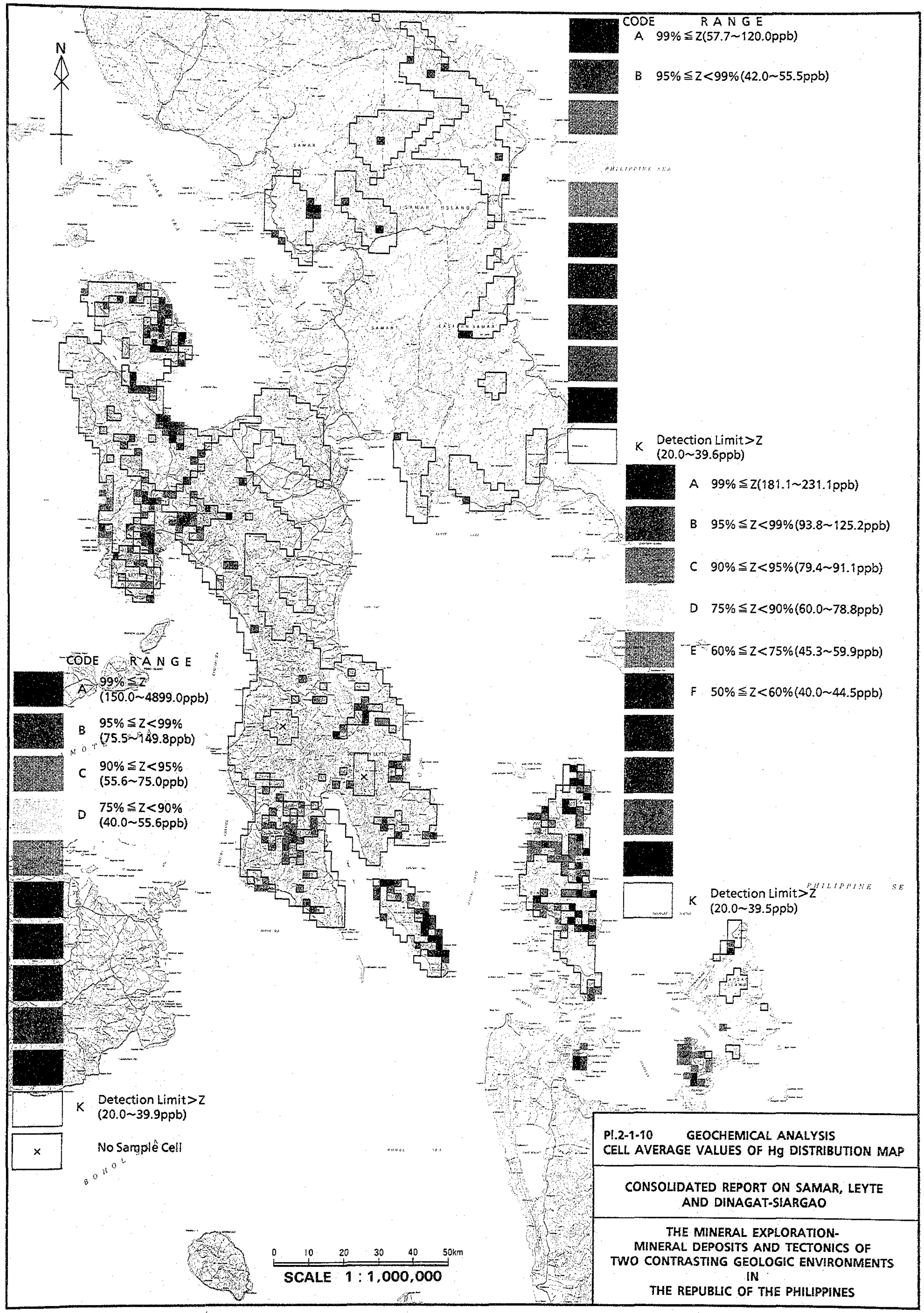

Pl.2-1-10 GEOCHEMICAL ANALYSIS CELL AVERAGE VALUES OF Hg DISTRIBUTION MAP

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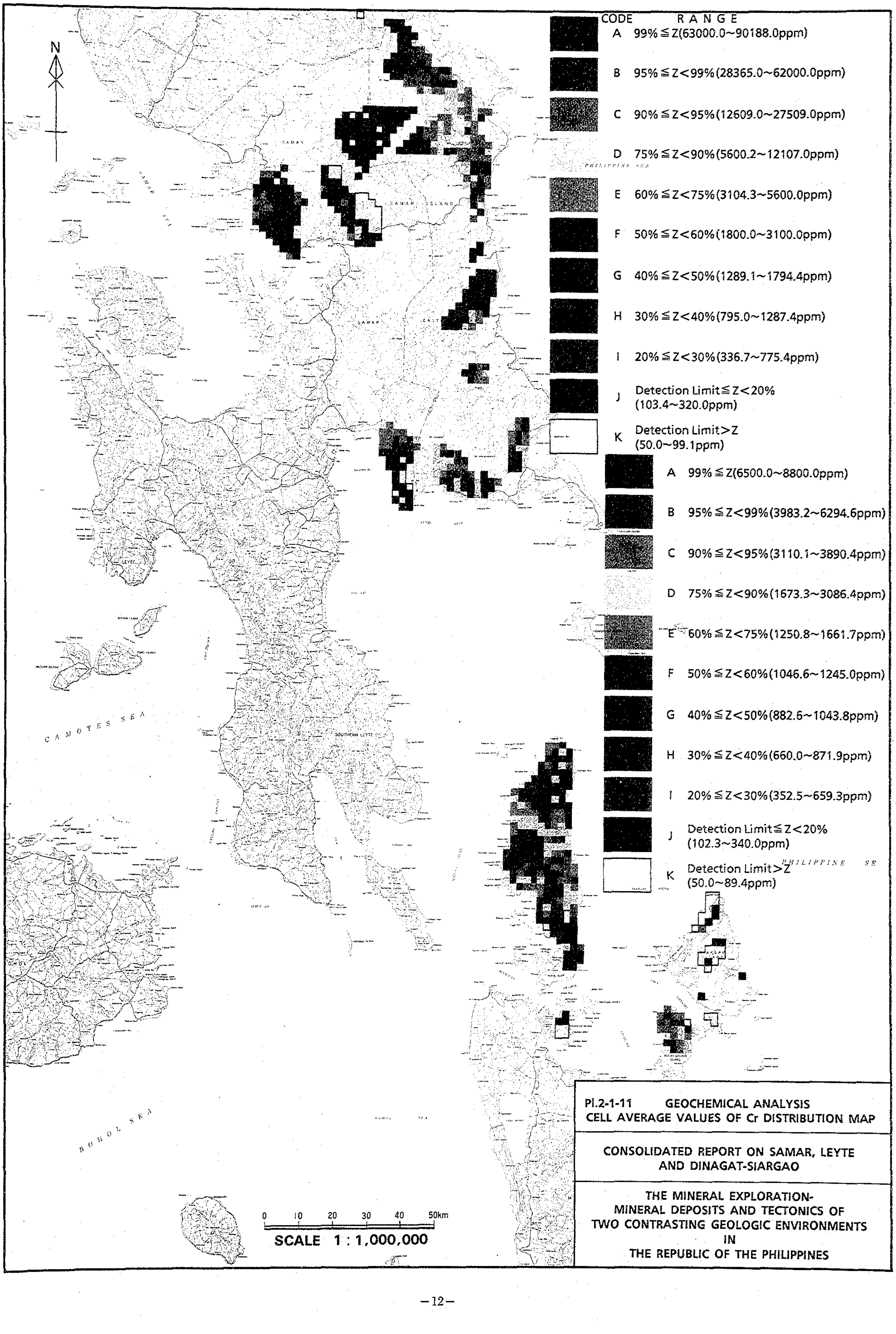

Pl.2-1-11 GEOCHEMICAL ANALYSIS
CELL AVERAGE VALUES OF Cr DISTRIBUTION MAP

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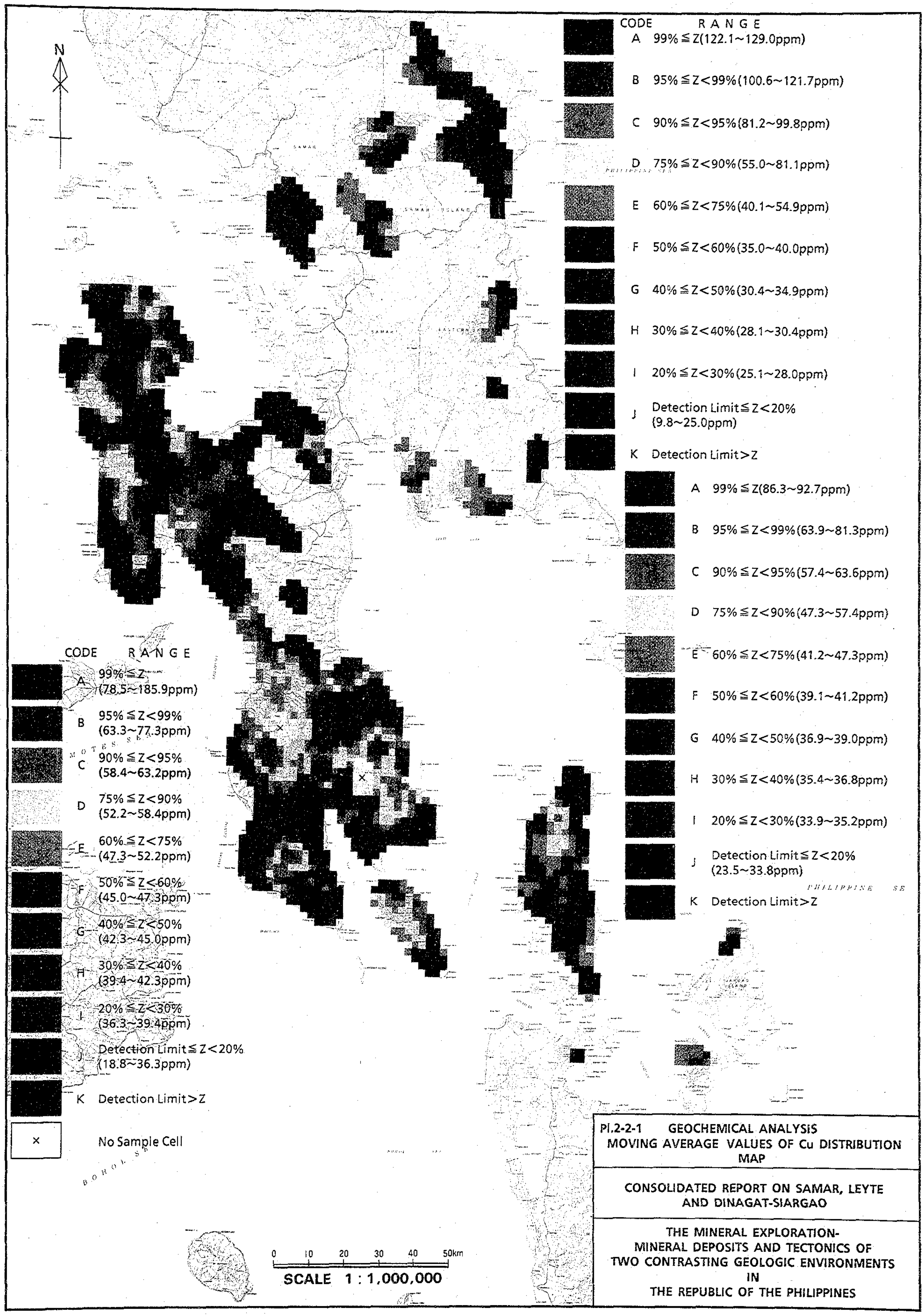
Pl.2-2 (No. 1 to No. 11) Geochemical Analysis Moving Average Values Distribution Map (1:1,000,000)



Pl.2-2-1 GEOCHEMICAL ANALYSIS
MOVING AVERAGE VALUES OF Cu DISTRIBUTION MAP

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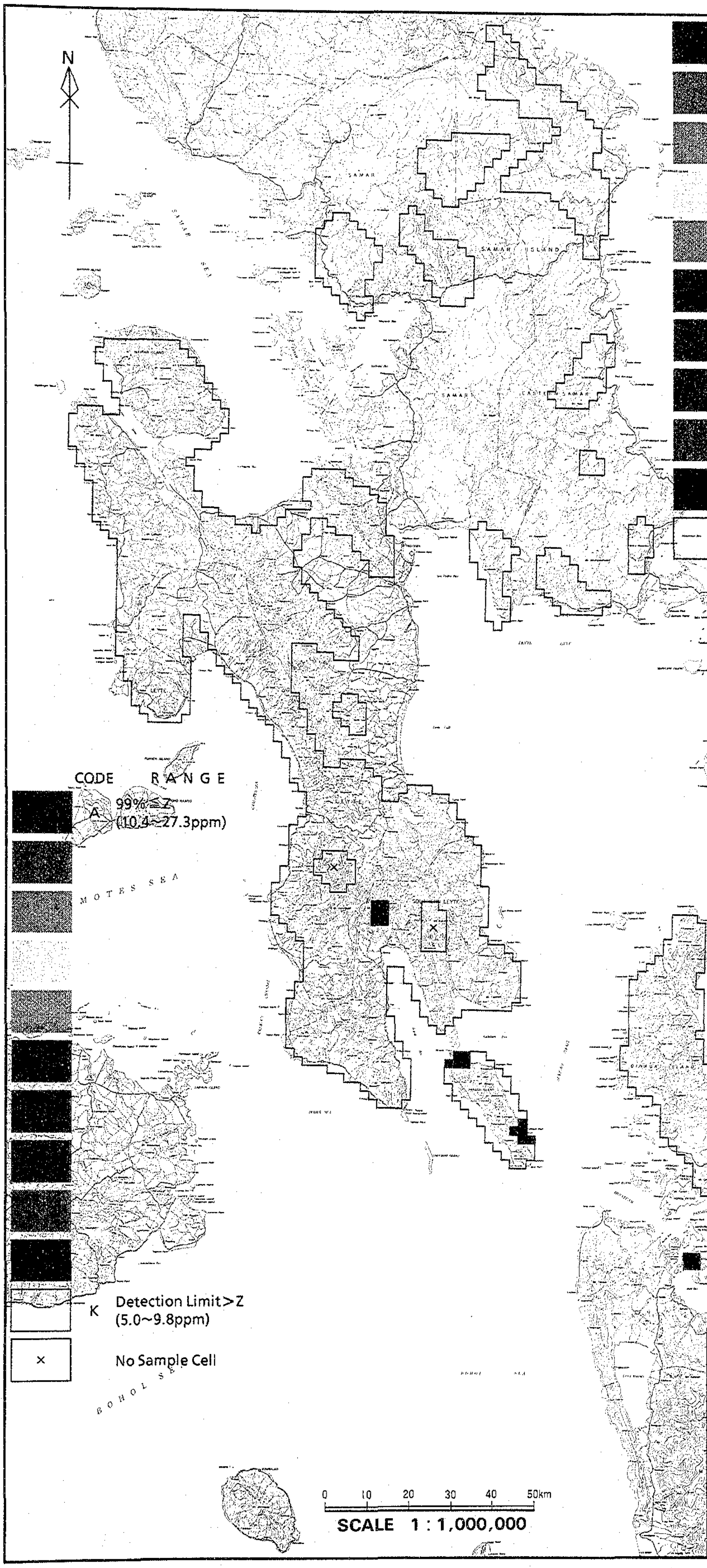

Pl.2-2-2 GEOCHEMICAL ANALYSIS MOVING AVERAGE VALUES OF Pb DISTRIBUTION MAP

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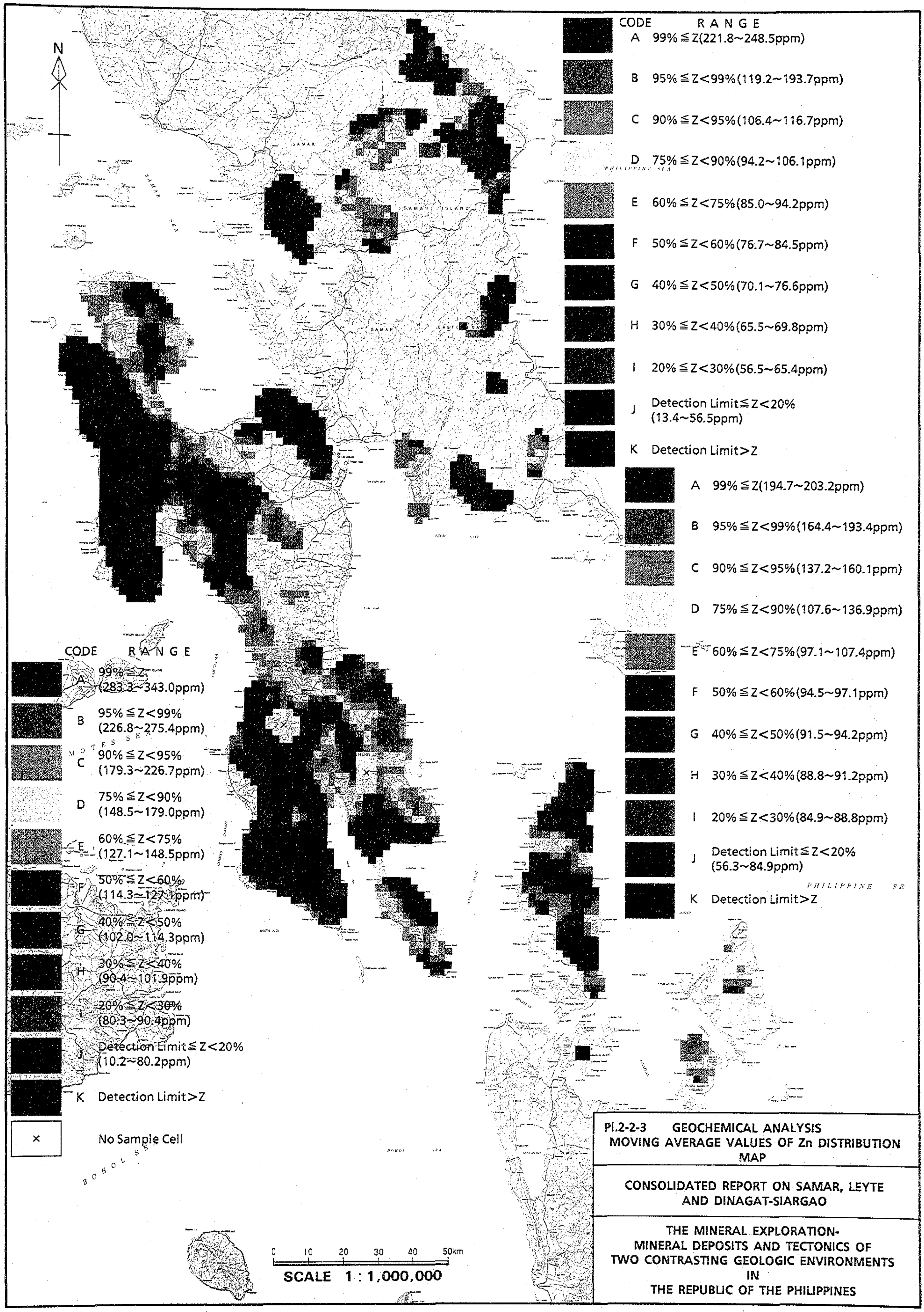

Pl.2-2-3 GEOCHEMICAL ANALYSIS
MOVING AVERAGE VALUES OF Zn DISTRIBUTION MAP

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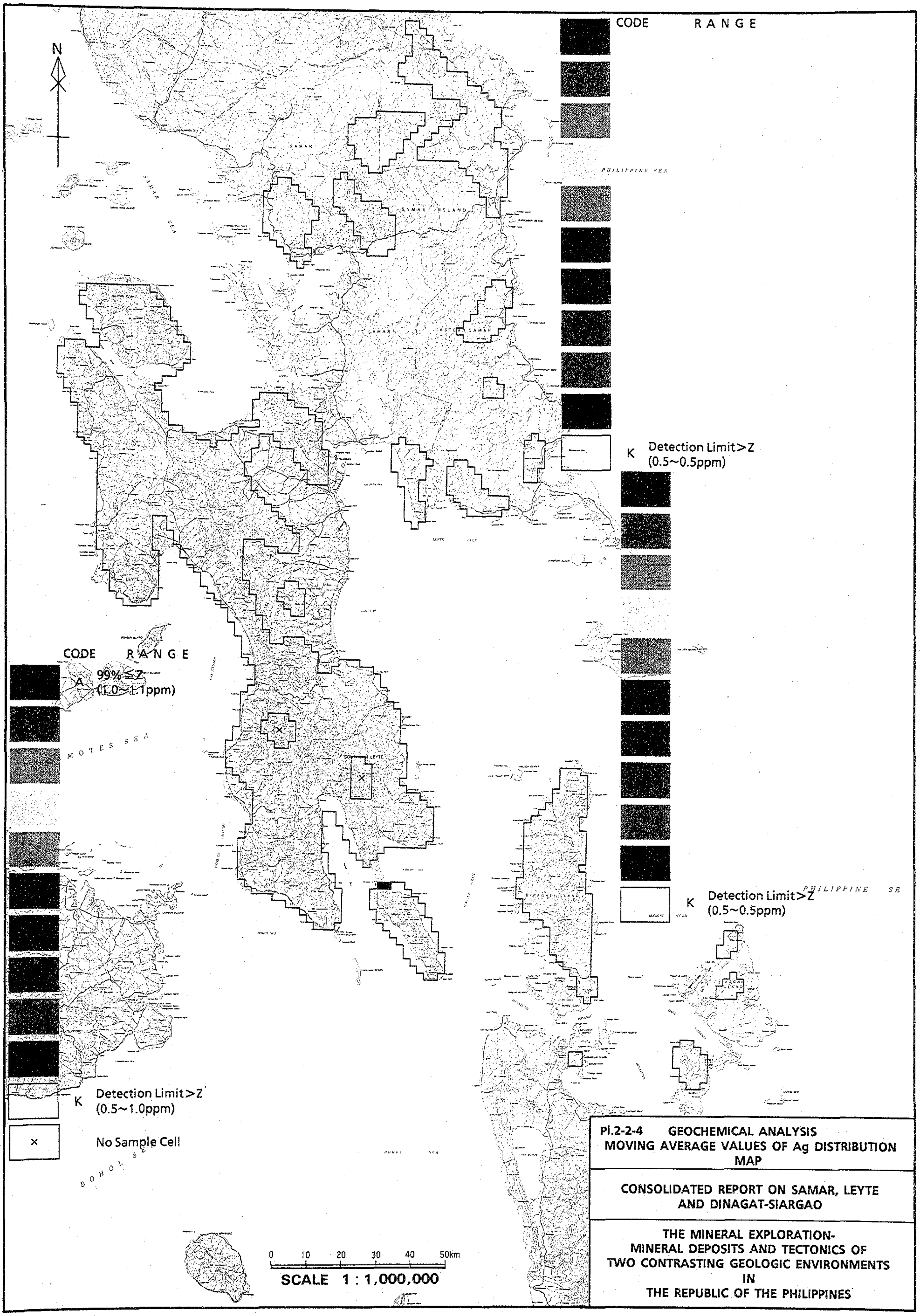

Pl.2-2-4 GEOCHEMICAL ANALYSIS
MOVING AVERAGE VALUES OF Ag DISTRIBUTION MAP

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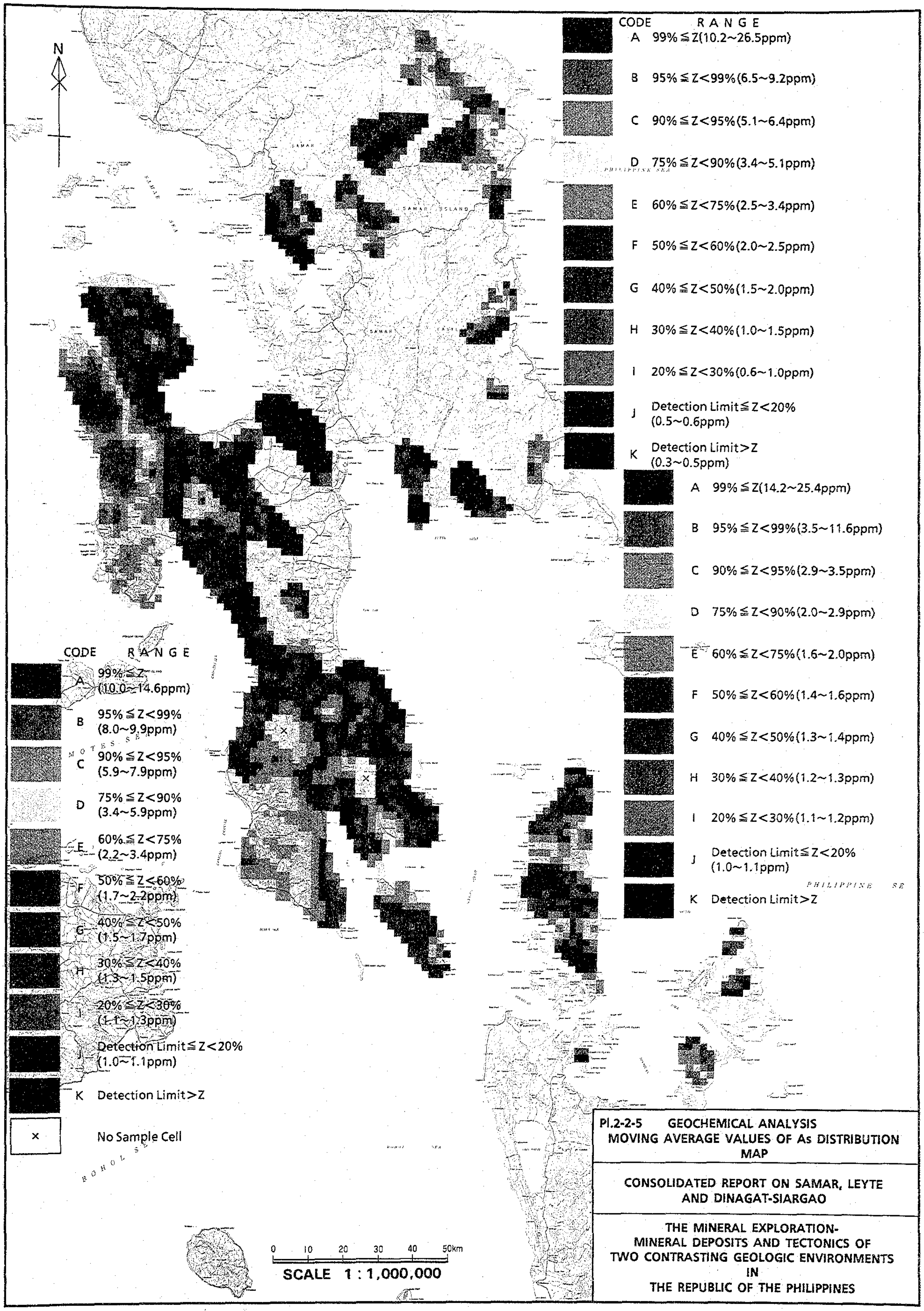

Pl.2-2-5 GEOCHEMICAL ANALYSIS MOVING AVERAGE VALUES OF As DISTRIBUTION MAP

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