Chapter 4 Statistical Analysis and Interpretation of Geochemical Data

In order to find the geochemical characteristics of the individual mineral occurrences in the investigated area, multivariate analysis (principal component analysis) was carried out using the geochemical analytical data acquired in both the Phase-1 and Phase-2.

4.1 Geochemical analytical data used

Analytical results of 384 samples out of 400 samples (180 from the Phase-1 and 220 from Phase-2) were used for the statistical analysis. As to the excluded 16 invalid samples, some were suffered from the mutual interference effects of Bi and P, and some others were out of scale in Ca and Mg. The analyzed elements are following 28 elements: Au, As, Sb, Hg, Ag, Al, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, P, Pb, Sr, Ti, V, W and Zn.

4.2 Preparation of analytical data before processing

Prior to the data processing, trace-level elements indicated in ppm were converted into logarithmus and indicated with a prefix "log" as in Log Au. These are as follows: Au, As, Sb, Hg, Ag, Ba, Be, Bi, Cd, Co, Cr, Cu, Mn, Mo, Ni, P, Pb, Sr, V, W and Zn. The histograms of the individual elements are shown in Fig.II-4-1.

4.3 Data processing method and results

4.3.1 Data processing method

Principal component analysis (PCA) was adopted in order integratedly to explain the geochemical distribution of elements in the area using fewer variables. Data processing was actually carried out using a subset version of the program package for Medical Statistic Analysis (NAP VER.4.0), which was down loaded through the Internet.

4.3.2 Results of processing and their interpretation

The principal component loading value after the varimax rotation are shown in Table II-4-1.

The PC1 shows a strong negative correlation(load <-0.6) with Ag, Cd, Au, Pb, Sb, Hg and Bi, and subsequently negative correlation(load <-0.4) with As, Cu and Zn. Since these are the elements accompanied with a hydrothermal deposit, PC1 might imply hydrothermal mineralization (Au, Ag, Cu, Pb, Zn)

The PC2 shows mainly a strong positive correlation (load >-06) with Sr, P, V, Ti and Al. Among these elements, the relationship of Al and P with APS minerals in the advanced argillic alteration suggests that this PC2 might indicate the advanced argillic alteration.

The 3rd principal component mainly shows a strong positive correlation (load >0.6) with Ni, Co, Mg, Fe and Mn. In general, Ni, Co, Mg and Fe are constituents of Mg-Fe minerals themselves or elements accompanied with them, so they are expected to become more concentrated in basic rocks. Therefore, it is inferred that the PC3 might be related with the composition of original rocks, and the higher score a sample has, the stronger it has the characteristics of a basic rock.

The PC4 mainly shows a strong negative correlation (load <-0.6) with K, Be, Na and Al. As each of them is a constituent element of acidic rocks, the group is inferred to be a principal component related with the composition of original rocks. But the lower is the score, the stronger are the characteristics as an acidic rock, since the loaded value is negative.

The PC5 mainly shows a strong positive correlation (load>0.6) with Ca and a negative correlation (load<-0.4) with As. This means that Ca and As have a negative correlation. It is difficult, however, to find a meaningful interpretation of this component, as the number of related elements is too small.

The PC6 shows a strong correlation (load =-0.873) with W. Next to this, the load value of Bi is –0.444. It might be interpreted that the component simply indicates the mineralization of W-Bi. But detail is not known as the number of related elements is too small.

The PC7 mainly shows strong negative correlation (load <-0.6) with Mo and Cu. Cu/Mo is a typical combination represented by the Erdenet deposit. Therefore it is inferred that this principal component is related with the porphyry type copper/molybdenum mineralization. It could be said that the smaller the score of the principal component of a sample is, the stronger the sample is related with the mineralization of the porphyry type copper/molybdenum, since both of the load values are negative.

4.3.3 Geochemical characteristics of individual mineral occurrences

Major mineral occurrences are classified by geochemical characteristic features based on the principal component scores of the individual samples and the interpretation of the principal components mentioned above. The principal component scores of the individual samples (Table II-4-2) were computed from the principal component loading matrix (Table II-4-1) and analytical values.

Based on the scores of the PC1, 2 and 7 considered being related with alteration and mineralization, out of 7 principal components mentioned above, mineral occurrences in the investigate area are classified into following five major groups (Table II-4-3). Here, the three components are.

A-group: The minereal occurrences which have mainly high scores of the PC2 (loaded values of the principal component are positive and high) . The mineral occurrences that belong to this group are as follows: Tsagaan chuluut, the proximity in the Erdenet NW deposit, Khujiriin gol, Mogoin gol 2, Under and Davaa in the Erdenet district. Mt.Zain Gobaav,Bulgan and Jasiin buuts in the Bulgan district. Urmiin tsagaan nuur in the Bulgan West district. Bulgan NW in the Erdenet West district. Gatsuunkhan in the Zelter district. All of these are in the eastern half of the investigated area (Phase-1 Area) and are mostly situated in the proximity of the Erdenet deposit and to its west.

B-group: The mineral occurrences which have mainly high scores of the PC7 (loading values of the principal components are negative and high). The mineral occurrences that belong to this group are as follows. The Erdenet Central deposit and its proximity in the Erdenet district, Undrakh in the Bulgan West district and Zost uul in the Tosontsengel district. Most of these are in the eastern half of the investigated area and situated in the proximity of the Erdenet deposits and to its west.

C-group: The mineral occurrences that have mainly high scores of the PC1 (loading values of the principal component are negative and high). The mineral occurrences that belong to this group are as follows. Oyuut khonkhor in the Bulgan SW district, Tsookher mert in the Bulgan district and so forth. The group occurs in the western half of the investigated area as well, other than in the southwest of the proximity of the Erdenet deposit.

D-group: The mineral occurrences that have high scores of both the PC1 and PC7. The mineral occurrences that belong to this group are as follows. The Ereen and Teshig deposits in the Tavt district, Tsagaan tolgoi in the Murun West district and Naranbulag in the Tosomtsengel district.

All of these are situated in the western half of the investigated area.

X-group: The mineral occurrences that do not have high scores in all of the PC1, PC2 and PC7. The mineral occurrences that belong to this group are Tourmaline in the Erdenet district and so forth. Details have not yet been clear for this group, as analytical data are only available less than 10 samples in an occurrence and mostly as few as 5 samples per occurrence.

4.3.4 Individual principal component vs. characteristic features of alteration

With regard to the three principal components (PC1, PC2 and PC7) which are interpreted to be related with mineralization or hydrothermal alteration (PC1, PC2 and PC7)), characteristic features of alteration are examined sample by sample. The principal components and characteristic features of the identified alteration minerals are shown in Table II-4-4.

The samples which show high scores of the PC1 have a characteristic feature of the alteration by the neutral pH hydrothermal fluid, as sericite was identified in all the 13 samples undergone X-ray diffraction test. However, there is also a possibility that acid hydrothermal fluid superimposed on the neutral hydrothermal alteration, or the neutral fluid itself changed into acid, since alunite in a sample and kaolinite in three samples were identified associated with sericite respectively.

With regard to 42 samples which show high scores of the PC2 and underwent the powder X-ray diffraction test, following alteration minerals were identified: Sericite in 18 samples, kaolinite in 14 samples, alunite + kaolinite in 8 samples, alunite in 5 samples and andalusite in 4 samples respectively. This indicates the alteration from the acid hydrothermal fluid, and moreover, the fact that alunite and/or andalusite were identified indicates that this component might be related with the advanced argillic alteration as mentioned in previous 4-3-2.

With regard to the samples that show high scores of the PC7, sericite was identified as an alteration mineral from 7 out of 13 samples that underwent the powder X-ray diffraction test, but no alteration mineral was identified from other samples. From this, the samples that show high scores might be characterized by the alteration from the neutral hydrothermal fluid, although it is not so strong.

As described above, the sample by sample examination of the analytical data also makes it possible to classify the individual principal component by the characteristic features of alteration.

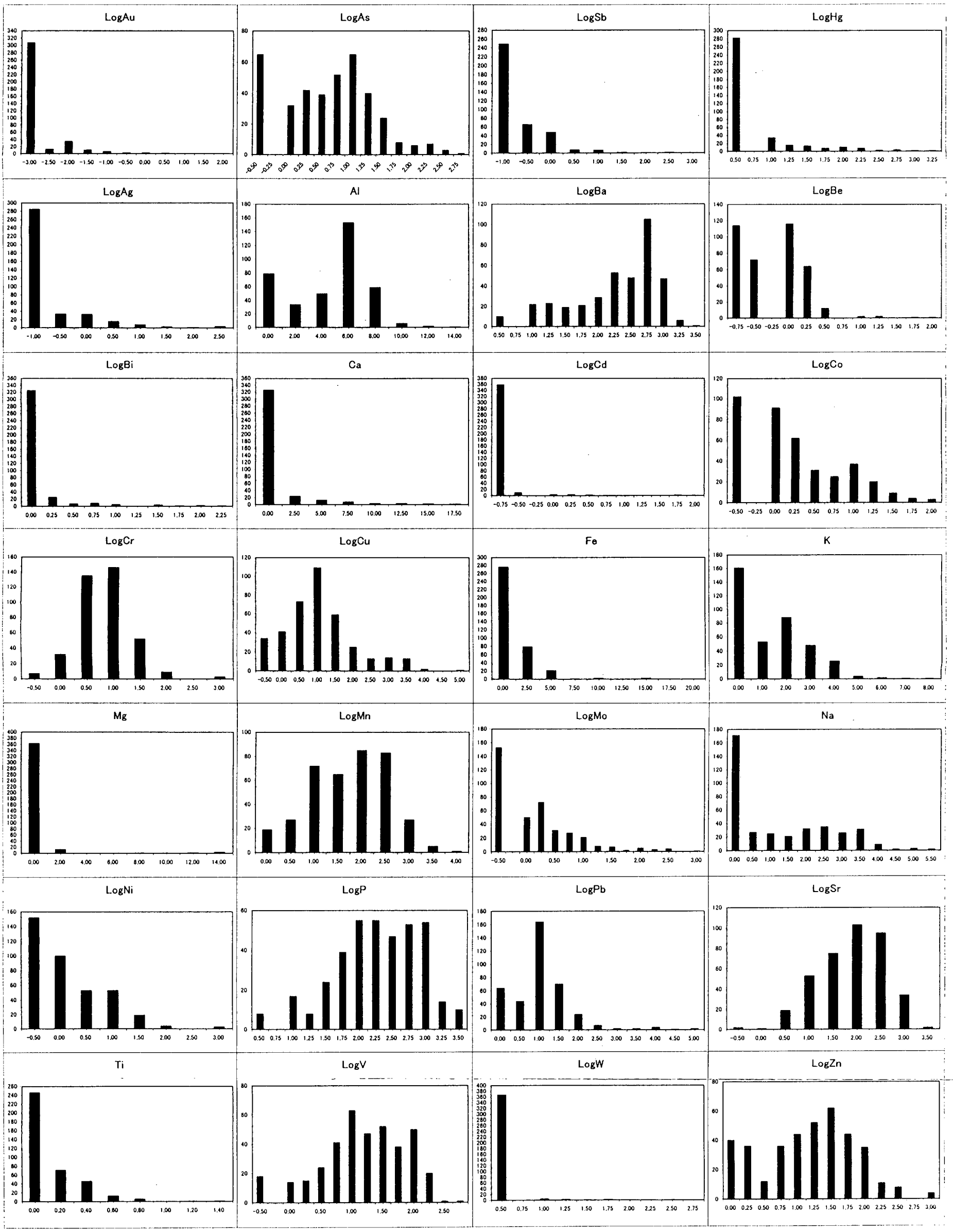

Fig. II-4-1 Histograms of the individual elements used for the multivariate analysis

Table II-4-1 Principal component matrix

Variables	PC1	PC2	PC3	PC4	PC5	PC6	PC7	Communality
LogAu	**-0.768**	-0.092	0.029	0.097	0.063	-0.025	-0.268	0.685
LogAs	-0.406	0.045	0.035	0.009	-0.554	-0.349	0.042	0.599
LogSb	**-0.746**	0.101	0.024	0.065	-0.361	-0.239	0.113	0.772
LogHg	**-0.683**	0.114	0.089	0.170	-0.279	0.083	-0.050	0.603
LogAg	**-0.843**	-0.080	0.044	0.000	0.048	-0.034	-0.301	0.812
Al	0.093	**0.623**	-0.024	**-0.620**	0.092	0.068	0.024	0.796
LogBa	0.022	0.516	-0.172	-0.516	-0.347	0.224	-0.055	0.736
LogBe	0.019	0.055	0.131	**-0.772**	-0.054	-0.370	0.047	0.757
LogBi	**-0.643**	-0.098	0.032	0.106	0.099	-0.444	-0.167	0.670
Ca	0.012	0.254	0.301	0.104	**0.714**	-0.166	0.175	0.733
LogCd	**-0.840**	-0.136	-0.026	0.023	0.005	0.048	0.132	0.746
LogCo	-0.087	0.419	**0.785**	-0.227	0.141	-0.008	-0.074	0.876
LogCr	0.069	0.438	0.495	0.392	-0.215	-0.010	0.204	0.684
LogCu	-0.471	0.192	0.251	0.013	0.125	0.080	**-0.626**	0.735
Fe	-0.060	0.279	**0.659**	-0.031	-0.012	-0.087	-0.276	0.600
K	0.095	0.068	-0.163	**-0.778**	-0.243	0.038	-0.039	0.706
Mg	0.092	-0.107	**0.706**	0.097	0.142	0.038	0.107	0.560
LogMn	-0.078	0.112	**0.604**	-0.555	0.321	-0.155	0.095	0.827
LogMo	-0.119	-0.106	-0.157	0.023	-0.308	-0.299	**-0.638**	0.641
Na	0.107	0.201	0.120	**-0.666**	0.146	0.184	0.023	0.565
LogNi	-0.071	0.271	**0.836**	-0.007	-0.027	0.002	0.026	0.778
LogP	-0.089	**0.837**	0.257	-0.154	-0.045	0.046	-0.106	0.814
LogPb	**-0.763**	0.206	-0.051	-0.282	-0.008	0.069	0.018	0.711
LogSr	-0.042	**0.860**	-0.030	-0.209	0.237	0.051	0.030	0.845
Ti	0.110	**0.742**	0.271	-0.021	0.085	-0.031	0.108	0.657
LogV	-0.048	**0.834**	0.315	-0.044	-0.072	0.071	-0.068	0.813
LogW	-0.023	-0.107	0.037	-0.033	0.003	**-0.873**	-0.100	0.787
LogZn	-0.422	0.052	0.538	-0.589	0.070	-0.030	-0.012	0.822
Sum of squared loadings	4.693	4.168	3.669	3.380	1.628	1.549	1.245	
Contribution	16.762	14.887	13.102	12.072	5.814	5.534	4.446	
Sum of contributions	16.762	31.649	44.751	56.823	62.637	68.171	72.617	

Remarks; Bold number shows loading more than 0.6 or less than -0.6

Table II-4-2 Principal component scores of individual samples in the central north area

Original No.	Sample No.	District	Occurrence	Rock name	Estimated SiO2%	PC1	PC2	PC3	PC4	PC5	PC6	PC7
1	M00NK103	Erdenet West	Undrakh	Quartz vein	86	-0.643	-1.106	0.450	-0.185	0.453	0.448	-2.616
2	M00NK104	Erdenet West	Undrakh	Granitoid	81	-0.258	-0.880	-1.084	-0.676	1.073	1.309	-2.890
3	M00NK105	Erdenet West	Undrakh	Quartz vein	98	-0.247	-2.736	-0.009	3.070	0.332	0.452	-3.630
4	M00NK106	Erdenet West	Undrakh	Granitoid	77	1.157	-0.248	-0.435	-1.580	-0.154	1.032	-1.004
5	M00NK109	Erdenet West	Undrakh	Quartz vein	99	0.795	-3.307	-0.272	2.987	0.217	0.272	0.114
6	M00NK110	Erdenet West	Undrakh	Aplite	77	0.739	-1.564	-1.818	-2.057	0.592	0.954	-1.027
7	M00NK111	Erdenet West	Danbatseren	silicified rock	99	0.943	-1.233	-0.544	2.461	-0.790	-0.260	0.118
8	M00NK114	Bulgan SW	Oyuut khonkhor	Network silicification	83	-1.354	0.493	1.357	-0.669	-1.189	-0.262	0.373
9	M00NK115	Bulgan SW	Oyuut khonkhor	Network silicification	71	-2.833	0.924	1.717	-2.375	-1.075	0.434	1.600
10	M00NK120	Bulgan SW	Oyuut khonkhor	silicified rock	89	-1.635	-0.351	1.138	0.486	-0.817	0.404	0.987
11	M00NK121	Bulgan SW	Oyuut khonkhor	silicified rock	89	-1.609	0.692	1.002	0.970	-1.020	0.147	0.384
15	M00NK135	Erdenet West	Tsagaan chuluut East	Andesite?	79	-0.644	0.849	-1.880	0.374	0.101	0.843	-0.340
16	M00NK137	Erdenet West	Tsagaan chuluut East	silciified rock	79	0.374	-1.527	-0.374	-1.658	-1.345	0.340	0.097
17	M00NK138	Erdenet West	Tsagaan chuluut East	Andesite?	68	-0.327	2.120	0.378	-0.488	-1.121	0.165	-0.489
18	M00NK139	Erdenet West	Tsagaan chuluut East	Trachy andesite	65	0.218	1.535	2.101	-2.226	-0.638	0.060	0.964
19	M00NK140	Erdenet West	Tsagaan chuluut South	Andesite?	83	0.070	1.030	-1.782	0.906	-0.771	0.007	-0.484
20	M00NK141	Erdenet West	Tsagaan chuluut South	Rhyolite	80	0.452	0.749	-1.133	0.014	-0.480	0.549	0.254
21	M00NK142	Erdenet West	Tsagaan chuluut South	Rhyolite	86	0.721	1.959	-2.625	1.568	0.105	0.865	-0.423
22	M00NK144	Erdenet West	Tsagaan chuluut North	Trachy andesite	62	1.090	2.321	2.503	-1.616	0.228	0.503	0.235
23	M00NK146	Erdenet West	Tsagaan chuluut North	?	85	1.586	-1.128	2.667	2.518	-1.255	0.109	-2.319
24	M00NK147	Erdenet West	Tsagaan chuluut North	?	99	0.885	-1.861	0.769	2.479	0.229	0.693	-0.559
25	M00NK148	Erdenet West	Tsagaan chuluut North	tuff breccia	65	0.238	5.458	-2.785	0.835	-0.617	0.507	1.074
26	M00NK149	Erdenet West	Tsagaan chuluut North	tuff breccia	85	0.588	3.810	-1.700	2.121	-0.764	0.303	0.513
27	M00NK150	Erdenet West	Tsagaan chuluut North	tuff breccia	86	0.825	4.195	-2.420	3.028	-0.268	0.369	0.766
28	M00NK151	Erdenet West	Tsagaan chuluut North	tuff breccia	89	1.063	3.705	-1.370	2.188	-0.032	0.269	0.555
29	M00NK152	Erdenet West	Tsagaan chuluut North	tuff breccia	97	0.849	1.239	-1.267	2.811	0.105	0.434	0.196
30	M00NK153	Erdenet West	Tsagaan chuluut North	tuff breccia	85	0.819	1.356	-2.255	1.963	-0.065	0.169	0.164
31	M00NK155	Erdenet West	Mogoin gol South	?	74	0.418	-0.301	-1.288	-2.696	0.018	0.400	0.113
32	M00NK156	Erdenet West	Mogoin gol South	Andesite	58	-0.074	2.751	2.809	-0.020	0.361	-0.543	1.264
33	M00NK157	Erdenet West	Mogoin gol South	Andesite	77	-0.205	-0.736	0.653	-2.324	-1.132	-0.127	2.067
34	M00NK159	Erdenet West	Mogoin gol South	Microdiorite	60	-0.294	3.118	0.672	-1.593	1.191	-0.638	0.343
35	M00NK160	Erdenet West	Mogoin gol South	tuff	74	-0.109	-0.336	-1.101	-2.719	-0.537	0.065	-0.150
36	M00NK162	Erdenet West	Tsagaan chuluut	tuff	87	1.224	3.915	-0.959	2.885	-0.129	-0.051	-0.402
39	M00IH100	Tariat	Terkhiin tsagaan nuur	Quartz vein	99	0.453	-2.444	-1.318	1.496	0.457	-8.846	1.416
40	M00IH107	Tosontsengel	Davaa	Quartz veinlet network	88	1.149	-1.121	0.285	0.193	0.562	0.422	0.703
41	M00IH108	Tosontsengel	Quartzite	Syenite	78	0.914	-1.563	-1.273	-1.722	0.986	0.463	1.052
42	M00IH109	Tosontsengel	Quartzite	Silicified rock	81	0.972	0.200	-0.609	-0.779	-1.059	-0.356	0.218
43	M00IH110	Tosontsengel	Quartzite	Silicified rock	79	1.129	-2.009	-1.018	-1.973	-0.064	-0.162	0.200
44	M00IH113	Tsagaan uul	Khunkh tsakhir	Silicified rock	55	1.613	4.562	3.906	-0.641	-0.300	-0.671	0.379
45	M00IH115	Tsagaan uul	Khunkh tsakhir	Quartz vein	99	-3.106	-3.050	-1.050	2.332	1.223	-2.908	-0.528
46	M00IH119	Tsagaan uul	Tsagaan uul	Dolomite	60	1.314	2.936	3.053	-2.290	-2.148	-10.229	0.257
47	M00IH122	Tsagaan uul	Deed ulaan tolgoi	Quartz vein	76	2.733	0.490	-1.486	-1.262	-1.226	-4.768	-0.973
48	M00IH123	Tsagaan uul	Deed ulaan tolgoi	Quartz vein	80	1.756	-0.426	-0.921	-2.188	-1.148	-1.901	-0.895
49	M00IH124	Tsagaan uul	Deed ulaan tolgoi	Felsite dyke	88	1.616	-1.537	-0.799	-0.425	-0.917	-0.071	0.114
50	M00IH125	Tsagaan uul	Nariin azarga	Sandstone	77	0.117	-1.147	-0.737	-2.192	-0.856	0.025	0.192
51	M00IH128	Murun West	Tsagaan tolgoi	Granite	71	1.028	0.395	-0.510	-3.062	0.797	0.586	-1.324
52	M00IH129	Murun West	Tsagaan tolgoi	Granite	78	-2.056	-2.600	0.055	-4.150	0.453	0.795	1.253
53	M00IH131	Erdenet West	Tsookher mert	Quartz mass	98	-14.644	-2.025	-1.311	1.695	-0.313	0.167	1.890
54	M00IH132	Erdenet West	Tsookher mert	Quartz vein	92	-14.918	-2.141	-1.348	-0.661	0.458	0.950	0.446
55	M00IH133	Erdenet West	Tsookher mert	Quartz vein	89	-2.195	-1.077	-0.165	0.141	0.411	0.510	0.804
56	M00IH137	Erdenet West	Oyuut khonkhor	Gossan	83	-3.576	0.221	-2.293	0.349	-1.350	0.458	0.091
57	M00IH138	Erdenet West	Oyuut khonkhor	Quartz vein	89	-3.997	-0.264	-0.545	0.112	0.514	-1.444	-1.179
58	M00IH141	Erdenet West	Tsagaan chuluut East	Altered rock	83	0.250	-0.002	-1.920	0.190	-0.603	0.259	-0.006
59	M00IH142	Erdenet West	Tsagaan chuluut East	Silicified rock	84	0.317	0.332	-1.770	0.139	-0.768	-0.439	0.173
60	M00IH156	Erdenet West	Talbulag	Altered porphyritic rock	79	-0.388	3.822	-0.730	2.888	-0.991	0.326	0.840
61	M00IH157	Erdenet West	Talbulag	Silicified rock	94	-2.445	2.743	-0.470	3.040	-1.880	-0.872	-0.152
62	M00HH101	Tariat	Solongot	skarn	45	0.554	-0.007	3.077	0.473	3.749	-0.374	0.681
63	M00HH103	Tosontsengel	Zost uul	Quartz porphyry	73	0.467	-0.010	-0.510	-2.533	-0.437	0.615	-1.048
64	M00HH105	Tosontsengel	Zost uul	qz with py. (black crystal)	82	1.228	-0.352	-1.022	-0.482	-0.982	0.098	-2.254
65	M00HH106	Tosontsengel	Naranbulag	Granite, syenite	75	0.396	-0.397	-0.340	-1.555	1.715	1.267	-0.818
66	M00HH108	Tosontsengel	Naranbulag	Granitic rock	83	-2.902	0.012	1.668	-0.480	-0.937	-1.571	-3.042
67	M00HH112	Tosontsengel	Davaa	syenite	81	1.034	-1.144	-0.248	-1.849	0.648	0.839	-0.763
68	M00HH113	Tosontsengel	Davaa	silicified rock	95	1.290	-1.495	0.795	1.073	-0.013	0.279	0.493
69	M00HH114	Tosontsengel	Quartzite	Altered rock with quartz	83	1.282	-0.956	-0.090	-0.997	0.081	0.211	-1.039
70	M00HH115	Tosontsengel	Quartzite	silicified rock	77	1.056	-1.665	-1.290	-1.909	-0.035	-0.491	-0.004
71	M00HH116	Tosontsengel	Quartzite	silicified rock	90	1.744	-1.939	-1.527	1.091	0.505	0.028	-0.833
72	M00HH118	Tsagaan uul	Gurvan buudal uul	qz with mica	75	0.186	-3.993	0.278	-4.318	1.309	-0.552	1.192
73	M00HH124	Tsagaan uul	Tsagaan uul	schist	74	0.466	0.840	3.183	-1.864	-2.881	-1.470	1.411
74	M00HH127	Tsagaan uul	Deed ulaan tolgoi	Quartz vein in granite	87	0.720	-2.718	0.135	-0.693	-0.897	0.009	0.681
75	M00HH129	Tsagaan uul	Deed ulaan tolgoi	Breccia (quartz, felsite)	87	1.500	-1.575	-0.959	-0.109	-1.353	-0.453	0.051
76	M00HH136	Murun West	Ulaannuur	Grano-syenite with pyrite	80	1.531	-1.881	-0.556	-0.942	-0.870	-1.442	0.274
77	M00HH137	Murun West	Ulaannuur	silicified rock	89	0.675	-2.335	-0.758	0.533	-0.444	0.249	0.141
78	M00HH141	Erdenet West	Bulgan NW (Eastern part)	silicified andesite (or diorite)	68	0.720	1.759	0.481	-2.196	1.113	0.426	0.181
79	M00HH142	Erdenet West	Bulgan NW (Eastern part)	silicified rock	72	-0.566	1.011	0.668	-1.597	-1.020	-0.385	0.470
80	M00HH143	Erdenet West	Burged Khyr	Granite	67	0.649	1.158	1.139	-2.437	-0.064	0.459	0.139
81	M00HH144	Erdenet West	Burged Khyr	silicified rock	78	0.634	-1.589	-0.599	-1.869	-0.417	-0.010	0.713
82	M00HH148	Erdenet West	Danbatseren	silicified rock	97	1.510	-1.530	-0.250	2.546	-0.570	-0.053	-0.540
83	M00HH149	Erdenet West	Danbatseren	silicified rock	92	1.239	-0.550	1.059	2.632	-1.660	-0.254	-1.392
84	M00HH150	Erdenet West	Danbatseren	silicified rock	98	0.647	-0.744	-0.467	2.701	-1.723	0.483	-0.803
85	M00HH151	Erdenet West	Danbatseren	silicified rock	97	1.753	-1.593	-0.461	2.764	-0.127	0.293	-1.188
86	M00HH152	Erdenet West	Danbatseren	silicified rock	99	1.786	-2.631	-1.054	2.776	-0.205	0.499	-0.494
87	M00HH153	Erdenet West	Danbatseren	silicified rock	97	1.588	-1.125	0.037	2.842	-0.800	0.037	-0.653
88	M00HH154	Erdenet West	Danbatseren	silicified rock	98	-0.615	-1.296	-0.336	3.549	-0.357	0.426	0.285
89	M00HH155	Erdenet West	Danbatseren	silicified rock	97	0.755	-0.507	-0.308	2.368	-0.041	-0.304	-0.997
90	M00HH156	Erdenet West	Danbatseren	silicified rock	95	0.725	-0.657	-0.124	2.211	-0.543	-0.031	-0.928

Table II-4-2 Principal component scores of individual samples in the central north area

Original No.	Sample No.	District	Occurrence	Rock name	Estimated SiO2%	PC1	PC2	PC3	PC4	PC5	PC6	PC7
91	M00HH157	Erdenet West	Danbatseren	silicified rock	98	1.090	-1.041	-1.012	2.375	-1.850	0.111	-1.100
92	M00HH158	Erdenet West	Danbatseren	silicified rock	99	1.850	-1.653	-0.003	2.326	-1.634	0.376	-1.055
93	M00HH159	Erdenet West	Danbatseren	Altered rock	79	0.771	2.281	-1.867	1.186	-0.894	0.072	0.375
94	M00HH160	Erdenet West	Danbatseren	silicified rock	95	-0.795	0.074	-0.656	2.334	-1.106	-0.694	-0.645
95	M00HH161	Erdenet West	Danbatseren	silicified rock	93	1.517	-0.624	0.584	2.133	-1.214	0.054	-0.920
96	M00HH162	Bulgan SW	Oyuut khonkhor	silicified rock	76	-1.823	1.166	1.382	-0.745	-2.794	-0.013	-0.090
97	M00HH163	Bulgan SW	Oyuut khonkhor	Tuff Breccia	70	-0.779	1.485	1.081	-1.502	-0.754	0.160	0.438
98	M00HH164	Bulgan SW	Oyuut khonkhor	silicified rock	87	-2.429	0.860	3.440	-0.199	-2.408	-0.712	-0.254
99	M00HH165	Bulgan SW	Oyuut khonkhor	silicified rock with limonite	84	-1.904	1.290	2.221	0.739	-0.790	-1.472	-0.540
100	M00HH166	Bulgan SW	Oyuut khonkhor	Andesite	58	-0.092	3.670	2.794	-1.299	-0.660	-0.922	0.779
101	M00HH167	Bulgan SW	Oyuut khonkhor	silicified rock (weakly)	74	-1.760	2.255	3.226	-0.105	-1.883	0.076	0.522
102	M00HH171	Tavt	Ereen No.42 ore body	Quartz	98	-0.560	-2.117	0.209	2.097	1.181	0.541	-1.452
103	M00HH172	Tavt	Ereen No.42 ore body	Altered rock	59	-2.156	2.266	1.513	-2.364	0.363	0.454	-1.429
104	M00HH174	Tavt	Column No.2	Ore	84	-4.642	-1.578	0.671	1.757	1.325	-4.105	-7.000
105	M00HH177	Tavt	Teshig No.2	Magnetite skarn	51	0.291	1.612	4.542	-0.182	0.533	1.110	-2.916
106	M00HH178	Zelter	Occurrence 24	Lappilli tuff (or granitic rock)	70	-1.458	0.740	0.575	-2.461	-0.540	0.443	-0.289
107	M00HH181	Erdenet West	Tsagaan chuluut East	silicified rock	85	0.232	0.236	-1.471	0.356	-0.362	0.303	0.020
108	M00HH182	Erdenet West	Tsagaan chuluut East	silicified rock	82	0.107	1.280	-2.493	0.718	-0.188	0.234	0.162
109	M00HH183	Erdenet West	Tsagaan chuluut East	silicified rock	82	0.146	0.854	-2.228	0.577	-0.389	0.226	0.700
110	M00HH184	Erdenet West	Tsagaan chuluut East	silicified rock	80	-0.256	1.254	-1.889	-0.229	-0.890	0.041	-0.118
111	M00HH185	Erdenet West	Tsagaan chuluut East	silicified rock	86	-0.365	-0.025	-2.154	0.007	-0.403	0.044	0.810
112	M00HH190	Erdenet West	Tsagaan chuluut North	Breccia of silicified rock	82	0.452	3.217	-2.186	1.619	0.059	0.611	0.394
113	M00HH195	Erdenet West	Tsagaan chuluut North	silicified rock	98	1.379	-1.008	0.276	2.707	-0.598	0.040	-0.338
114	M00HH196	Erdenet West	Tsagaan chuluut NE	silicified (altered) rock	82	0.396	4.363	-1.735	2.607	-0.407	0.796	0.565
115	M00HH197	Erdenet West	Mogoin gol South	silicified rock	82	1.742	1.340	-1.792	2.350	-0.776	0.070	-0.668
116	M00HH198	Erdenet West	Mogoin gol South	Altered rock	86	0.497	2.296	-2.497	1.108	-0.426	0.022	-0.233
117	M00HH200	Erdenet West	Mogoin gol South	Altered rock	87	1.641	2.025	-1.995	2.986	-0.054	-0.095	-0.632
118	M00HH202	Erdenet West	Khujiriin gol	Quartz vein	99	-2.248	-1.961	-0.003	2.272	-0.644	-0.260	0.065
120	M00MZ100	Tariat	Terkhiin tsagaan nuur	Quartz vein	100	-1.403	-3.492	-1.067	1.833	1.055	-7.126	0.106
121	M00MZ101	Tariat	Terkhiin tsagaan nuur	Quartz vein	98	1.479	-4.120	0.460	-1.491	-0.540	-9.106	1.284
122	M00MZ102	Tariat	Solongotiin gol	Skarn	50	1.265	3.053	3.029	0.217	1.214	-5.081	-0.002
123	M00MZ104	Tosontsengel	Khuurai sair	Felsite	78	0.211	-0.072	-1.227	-2.164	0.151	-1.783	-1.692
124	M00MZ105	Tosontsengel	Khuurai sair	Felsite	84	-5.776	-0.272	0.213	-0.056	1.910	-0.194	-2.256
125	M00MZ106	Tosontsengel	Zost uul	Altered rock	73	1.043	1.305	-0.625	-0.922	-1.188	0.263	-1.800
126	M00MZ107	Tosontsengel	Zost uul	Altered rock	76	1.492	0.411	-0.254	-1.659	-1.152	-0.007	-3.219
127	M00MZ108	Tosontsengel	Zost uul	Altered rock	82	1.292	-0.420	-1.522	-0.691	-0.844	0.335	-1.653
128	M00MZ109	Tosontsengel	Naranbulag	Granite	75	0.239	-0.164	-0.045	-1.502	0.748	0.714	-0.440
129	M00MZ110	Tosontsengel	Naranbulag	Aplite	81	-0.481	0.173	-1.831	-0.444	-0.656	0.656	-0.489
130	M00MZ114	Tosontsengel	Occurrence 124-B-4.5	Gabbro	47	0.591	0.423	2.571	-0.217	2.241	0.634	-0.437
131	M00MZ115	Tosontsengel	Davaa	Altered rock	96	1.248	-1.528	0.095	1.364	-0.193	0.129	0.288
132	M00MZ116	Tosontsengel	Quartzite	Rhyolite	77	0.651	-1.575	-1.346	-1.827	-0.297	-0.209	-0.356
133	M00MZ118	Tsagaan uul	Gurvan buudal uul	Quartz vein	83	0.629	-0.760	-0.423	-0.810	1.397	0.847	0.311
134	M00MZ120	Tsagaan uul	Gurvan buudal uul	Quartz vein	99	0.756	-3.392	-0.471	2.214	0.055	-0.289	1.183
135	M00MZ121	Tsagaan uul	Khunkh tsakhir	Altered rock	88	-1.795	-3.611	-0.840	-1.646	1.273	-4.164	0.052
136	M00MZ122	Tsagaan uul	Khunkh tsakhir	Altered rock	81	-2.563	-3.917	0.241	-2.529	1.045	-3.509	-0.825
137	M00MZ123	Tsagaan uul	Tsagaan uul	Mudstone	99	-4.217	-1.040	2.348	2.829	-3.300	0.455	1.137
138	M00MZ124	Tsagaan uul	Tsagaan uul	Quartz vein	98	-1.449	0.480	1.137	3.072	-1.896	0.391	-0.447
139	M00MZ125	Tsagaan uul	Ulaan zavsar	Quartz vein	88	1.018	-1.800	-0.038	0.538	0.451	0.543	0.448
140	M00MZ126	Tsagaan uul	Ulaan zavsar	Siliceous rock	83	0.547	-0.509	0.681	-0.447	0.091	0.411	0.559
141	M00MZ127	Tsagaan uul	Ulaan zavsar	Gneissose rock	78	0.432	-0.171	1.478	-1.202	-0.163	0.338	0.851
142	M00MZ128	Tsagaan uul	Khaisiin belchir	Pelitic schist	81	-1.799	1.144	2.127	1.007	-2.501	0.273	-0.158
143	M00MZ129	Murun west	Ulaannuur	Greisen	78	2.245	-1.685	-0.672	-1.189	-1.072	-2.717	-0.681
144	M00MZ133	Erdenet West	Bulgan NW (Eastern part)	Sil. rock	80	0.865	-0.605	-1.436	-1.861	-0.524	-0.110	1.128
145	M00MZ134	Erdenet West	Bulgan NW (Eastern part)	Sil. rock	72	0.052	0.866	0.029	-1.964	-0.412	-0.271	0.146
146	M00MZ135	Erdenet West	Burged khyr	Aplite	80	-0.446	-1.436	0.583	-1.671	-0.979	0.192	0.511
147	M00MZ136	Erdenet West	Burged khyr	Granitoid	77	0.209	-1.041	-1.131	-0.958	0.560	0.512	0.353
148	M00MZ139	Erdenet West	Burged khyr	Syenite	81	0.685	-1.499	-0.296	-1.410	-0.599	-0.161	0.830
149	M00MZ141	Erdenet West	Burged khyr	Granitoid	79	-0.155	-1.124	-1.366	-1.729	-0.192	-0.005	0.492
150	M00MZ142	Erdenet West	Burged khyr	Granite	78	-1.579	-1.079	1.092	-2.152	-2.060	-0.312	-0.696
151	M00MZ143	Erdenet West	Tsookher mert	Quartz vein	90	-0.672	-1.987	-0.448	0.530	0.607	0.389	0.535
152	M00MZ144	Erdenet West	Tsookher mert	Quartz veinlets	85	-0.423	-1.148	0.316	-1.279	0.634	1.230	0.072
153	M00MZ146	Bulgan SW	Oyuut khonkhor	Volcanic rock	67	-1.014	2.108	2.461	-1.921	-1.388	-0.184	-0.262
154	M00MZ147	Bulgan SW	Oyuut khonkhor	Volcanic rock	68	-1.784	2.596	1.025	-0.819	-2.431	0.131	0.066
155	M00MZ148	Bulgan SW	Oyuut khonkhor	Volcanic rock	70	-0.963	1.745	1.180	-1.264	-1.580	0.284	-0.237
156	M00MZ160	Zelter	Gatsuunkhan	Granite	76	-0.180	-1.395	0.597	-2.533	0.033	-0.018	-0.934
157	M00MZ161	Zelter	Gatsuunkhan	Porphyry dacite	68	0.288	1.577	1.655	-1.073	-0.547	-0.296	0.372
158	M00MZ164	Erdenet West	Tsagaan chuluut East	Altered rock	84	0.491	0.960	-2.649	1.278	-0.372	-0.420	0.143
159	M00MZ165	Erdenet West	Tsagaan chuluut East	Altered rock	81	-0.660	0.685	-1.714	0.556	-0.804	-0.094	-0.307
160	M00MZ167	Erdenet West	Tsagaan chuluut West	Altered rock	81	0.713	-1.981	-1.690	-1.646	0.587	0.450	0.759
161	M00MZ168	Erdenet West	Talbulag South	Altered rock	96	1.098	1.004	-1.605	2.787	-0.656	-0.289	0.265
162	M00MZ169	Erdenet West	Talbulag South	Altered rock	93	1.072	1.624	-2.263	2.647	-0.598	0.263	0.241
163	M00MZ171	Erdenet West	Mogoin gol North	Altered rock	85	0.497	2.413	-2.897	1.953	-0.376	0.386	0.560
164	M00MZ172	Erdenet West	Mogoin gol North	Altered rock	77	0.194	2.965	-3.252	1.078	-0.568	-0.001	0.996
165	M00MZ173	Erdenet West	Mogoin gol North	Altered rock	99	0.844	-0.909	-1.410	2.770	-1.141	0.228	-0.157
166	M00MZ178	Erdenet West	Khujiriin gol North	Altered rock	72	0.964	2.943	-3.311	-0.629	0.642	-0.026	-0.054
167	M00MZ179	Erdenet West	Khujiriin gol North	Altered rock	70	1.375	3.629	-1.561	2.161	-0.179	0.143	-0.187
168	M00MZ180	Erdenet West	Khujiriin gol North	Altered rock	72	1.035	2.390	-0.371	-0.548	-0.003	-0.706	-0.409
169	M00MZ183	Erdenet West	Talbulag	Altered rock	75	0.218	-0.617	-1.457	-2.553	-0.042	0.418	0.648
170	M00MZ184	Erdenet West	Talbulag	Altered rock	88	1.263	2.163	-2.516	2.535	-0.177	0.392	0.197
171	M00MZ185	Erdenet West	Talbulag East	Altered rock	93	-1.994	2.797	-1.934	3.235	-2.244	-0.068	0.402
172	M00MZ186	Erdenet West	Talbulag East	Altered rock	78	0.570	4.239	-3.274	2.100	-0.281	-0.454	0.067
173	M00TM100	Tariat	Terkhiin tsagaan nuur	Quartz vein	100	0.403	-3.720	-0.739	2.322	0.480	-0.629	0.932
174	M00TM102	Tariat	Tariatiin gol	Anorthosite	57	0.865	1.711	-2.559	-1.423	1.291	0.077	0.592
175	M00TM103	Tariat	Tariatiin gol	Quartz vein or mass?	100	1.529	-3.459	-0.742	2.895	0.161	0.748	0.349
176	M00TM104	Murun West	Tsagaan tolgoi	Quartz mass?	99	0.310	-1.797	-0.870	2.030	-0.549	-0.170	-0.470

Table II-4-2 Principal component scores of individual samples in the central north area

Original No.	Sample No.	District	Occurrence	Rock name	Estimated SiO2%	PC1	PC2	PC3	PC4	PC5	PC6	PC7
177	M00TM105	Murun West	Tsagaan tolgoi	Granite	73	1.090	0.363	-1.606	-2.171	-1.720	-0.275	-2.628
178	M00TM106	Murun West	Tsagaan tolgoi	Granite	75	1.380	0.001	-1.768	-2.121	-0.130	-0.028	-0.320
179	M00TM107	Murun West	Tsagaan tolgoi	Quartz pophyry?	81	-1.134	-1.770	-1.921	-1.906	-0.843	-1.117	-1.345
180	M00TM112	Erdenet West	Bulgan NW (Eastern part)	Quartz vein	59	-0.643	0.569	0.107	2.021	3.523	-1.070	0.057
181	M00TM113	Erdenet West	Undrakh	Aplitic Granite	86	-0.248	-1.292	-0.580	0.600	0.584	0.510	-1.115
182	M00TM114	Erdenet West	Tsookher mert	Quartz vein	94	0.554	-2.231	0.741	1.028	-0.398	0.436	0.462
183	M00TM116	Erdenet West	Tsookher mert	Granitic rock	77	0.918	-0.129	-0.280	-2.218	-0.090	0.561	0.124
184	M00TM117	Erdenet West	Tsookher mert	Granitic rock	65	-1.764	-0.077	-0.668	-3.240	1.041	0.791	-0.407
185	M00TM119	Bulgan SW	Oyuut khonkhor	Tuff breccia	74	-2.734	2.076	0.896	-0.782	-1.969	0.141	0.164
186	M00TM120	Bulgan SW	Oyuut khonkhor	Tuff breccia	67	-1.157	1.762	2.039	-0.839	-1.739	0.218	-0.219
187	M00TM121	Bulgan SW	Oyuut khonkhor	Tuff breccia	87	-1.619	0.637	1.623	0.498	-0.950	0.161	1.474
188	M00TM122	Bulgan SW	Oyuut khonkhor	Andesite	81	-0.602	1.159	0.558	1.009	0.252	-0.697	0.864
189	M00TM124	Bulgan SW	Oyuut khonkhor	Andesite (float rock)	78	-2.054	1.570	3.003	1.000	-0.701	-2.131	-0.819
190	M00TM125	Bulgan SW	Oyuut khonkhor	Tuff breccia (float rock)	91	-1.299	0.054	1.614	0.813	-1.050	-1.463	-0.171
191	M00TM127	Tavt	Ereen No.2 ore body	Quartz vein	99	-4.055	-0.706	-0.357	4.365	0.029	0.621	-4.100
192	M00TM130	Tavt	Ereen No.1 ore body	Quartz vein	85	-1.830	0.313	0.415	0.220	-1.369	0.989	-0.889
193	M00TM132	Tavt	Teshig No.2	Skarn ore	49	-2.225	1.892	3.149	0.597	3.035	0.444	-1.495
194	M00TM133	Zelter	Gatsuunkhan	Granitic rock (float rock)	68	-0.394	2.624	0.961	0.131	0.531	-0.939	0.404
195	M00TM134	Zelter	Gatsuunkhan	Granitic rock (float rock)	71	-0.653	1.736	2.789	-0.049	-0.601	-0.767	0.810
196	M00TM135	Zelter	Gatsuunkhan	Basalt? (float rock)	63	0.516	4.120	1.915	-1.115	-0.927	-0.950	0.658
197	M00TM136	Erdenet West	Under	Tuff breccia	77	0.535	-0.107	0.395	-1.757	0.311	0.386	0.176
198	M00TM137	Erdenet West	Under	Tuff breccia (float rock)	93	0.490	-1.345	0.148	0.797	-0.702	0.379	0.756
199	M00TM138	Erdenet West	Under	Quartz vein	82	-0.052	1.252	1.229	1.922	0.829	-0.260	0.429
200	M00TM139	Erdenet West	Under	Tuff breccia	66	0.748	1.929	1.950	-0.337	0.634	0.512	0.157
201	M00TM140	Erdenet West	Under	White altered rock (float rock)	81	1.814	-0.699	-1.071	-0.467	-1.065	-0.334	-0.155
202	M00TM142	Erdenet West	Under	Altered rock	82	1.595	-0.289	-0.443	-0.067	-0.830	0.053	0.423
203	M00TM143	Erdenet West	Tsagaan chuluut East	Altered rock	84	1.307	0.788	-2.728	1.510	-0.011	0.665	-0.208
204	M00TM145	Erdenet West	Tsagaan chuluut East	Altered rock	93	0.732	-0.377	1.248	1.290	-2.135	-0.502	-0.120
205	M00TM146	Erdenet West	Tsagaan chuluut East	Altered rock	91	0.640	0.518	-1.912	1.801	-0.960	0.016	-0.038
206	M00TM149	Erdenet West	Tsagaan chuluut West	Altered rock	84	0.194	0.669	-2.240	0.795	-0.073	0.420	-0.216
207	M00TM150	Erdenet West	Tsagaan chuluut West	Altered rock	85	0.289	0.364	-2.286	0.547	-0.614	0.134	0.324
208	M00TM152	Erdenet West	Tsagaan chuluut West	Trachite porphyry?	82	0.585	1.002	-2.217	0.513	-0.983	-0.068	0.318
209	M00TM153	Erdenet West	Tsagaan chuluut West	Altered rock	72	0.415	1.955	-0.634	-0.961	-1.487	-0.289	-0.010
210	M00TM154	Erdenet West	Tsagaan chuluut West	Tuff breccia	80	0.146	-0.576	-1.159	-1.066	0.385	0.625	0.322
211	M00TM155	Erdenet West	Talbulag South	Tuff breccia	80	0.225	4.202	-2.180	2.462	-1.116	0.303	-0.161
212	M00TM157	Erdenet West	Talbulag South	Tuff breccia	84	0.561	3.779	-2.230	3.143	-0.084	0.608	-0.422
213	M00TM158	Erdenet West	Talbulag South	Rhyolite	78	0.705	0.487	-1.186	-0.862	-0.917	0.048	1.102
214	M00TM160	Erdenet West	Mogoin gol South	Altered rock	81	1.060	-0.812	-0.849	-0.868	-0.179	0.024	0.312
215	M00TM162	Erdenet West	Khujiriin gol	Quartz vein	97	1.034	-1.914	0.738	1.339	-0.417	-0.023	0.932
217	M00TM169	Erdenet West	SAR139	Andesite porphyry	67	-0.508	2.176	1.601	-1.058	0.448	0.644	-1.841
218	M00TM170	Erdenet West	SAR139	Silicified rock	81	-0.374	0.032	-0.430	-0.006	1.030	1.078	-1.883
219	M00TM171	Erdenet West	Under North	Tuff breccia	74	0.556	-0.219	-0.493	-2.680	0.078	0.106	-0.007
220	M00TM172	Erdenet West	Chuluut	Granite	74	0.737	0.363	-0.553	-1.820	-0.508	-0.002	0.667
221	M99NK001N	Zaamar	Sudal N177	quartz vein	80	-4.173	-1.392	2.895	2.475	-0.464	-3.396	-3.501
222	M99NK002E	Zaamar	Sudal N177	granite	80	1.027	-0.988	-1.480	-1.146	0.385	0.962	0.172
223	M99NK003N	Zaamar	Sudal N177	quartz vein	97	1.662	-2.812	-0.315	2.198	0.216	0.562	0.250
224	M99NK004N	Zaamar	Sudal N177	quartz vein	100	1.650	-3.981	-0.703	3.007	-0.006	0.106	1.299
225	M99NK005N	Zaamar	Sudal N177	quartz vein	99	1.274	-3.252	-0.139	2.530	0.358	-0.262	1.064
226	M99NK006E	Zaamar	Sudal N177	slate	72	0.068	1.162	1.631	0.727	0.929	-0.657	1.130
227	M99NK007E	Zaamar	Ulziit ovoo	andesite	55	0.400	3.251	3.450	1.564	0.735	-0.961	2.857
228	M99NK008N	Zaamar	Ulziit ovoo	slate	42	1.751	-5.471	12.676	0.806	-0.674	2.567	-2.828
229	M99NK009E	Bulgan SW	Oyuut khonkhor	silicified rock	80	0.546	-2.113	0.355	-2.009	-0.389	0.157	1.086
230	M99NK010E	Bulgan SW	Oyuut khonkhor	silicified rock	74	-1.079	1.639	0.755	-0.566	-1.278	0.478	-0.017
231	M99NK011E	Bulgan SW	Oyuut khonkhor	silicified rock	86	0.311	0.586	1.835	0.694	-1.813	-0.353	-0.272
232	M99NK012E	Bulgan SW	Oyuut khonkhor	silicified rock	73	-1.559	2.072	1.072	-0.554	-1.122	-0.077	-0.882
233	M99NK013N	Bulgan SW	Oyuut khonkhor	hydrothermal breccia	71	-3.491	0.648	2.016	-1.210	-1.226	0.823	-0.028
234	M99NK014E	Uubulan	Holboo ovoo	andesite	60	0.183	2.486	1.375	-2.027	0.847	-0.242	1.081
235	M99NK015E	Uubulan	Mogoin gol	diorite	67	-5.570	-0.326	0.650	-1.858	4.107	-0.356	-1.555
236	M99NK016E	Uubulan	Gua ulaan uul	breccia	81	-0.914	-1.384	-0.758	-2.553	-1.163	-1.328	-1.318
237	M99NK017E	Khujirt	Zost tolgoi	granite	82	1.164	-2.148	-0.979	-0.957	-0.198	0.357	-0.274
238	M99NK018E	Khujirt	Zost tolgoi	andesite	67	1.533	2.143	1.808	1.789	1.496	-0.435	1.081
239	M99NK019E	Khujirt	Zost tolgoi	granite	80	0.894	-0.747	-1.893	-1.062	0.046	0.083	0.019
240	M99NK020N	Khujirt	Yargit	granite	79	0.008	-0.387	-0.357	-2.180	0.423	0.501	-3.421
241	M99NK021N	Murun South	Donhor bulag	quartz vein	97	0.577	-3.937	-0.174	1.401	0.162	0.596	0.176
242	M99NK022N	Murun South	Donhor bulag	quartz vein	91	-0.705	-1.685	0.384	-0.703	0.418	-0.056	-0.361
243	M99NK023E	Murun South	Donhor bulag	hydrothermal breccia	78	0.775	-3.261	0.373	-3.359	0.327	-0.769	1.617
244	M99NK024N	Altgana gol	Altgana gol	quartz vein	100	1.744	-4.980	-0.141	2.501	-0.268	0.170	0.875
245	M99NK027E	Khokhoo	---	andesite	61	1.031	2.954	3.095	-0.695	0.473	0.172	1.111
248	M99NK032E	Erdenet	Mogoin gol	quartzite gravel	99	1.542	-3.063	0.704	2.782	0.081	0.256	0.361
249	M99NK034E	Erdenet	Mogoin gol	granite	82	0.669	1.879	-1.667	1.756	0.215	0.511	-0.188
250	M99NK035E	Erdenet	Mogoin gol	granite	99	2.027	-2.779	-1.360	2.717	0.426	0.391	-0.249
251	M99NK036E	Erdenet	Mogoin gol	granite	100	1.846	-3.374	-1.049	2.794	-0.115	0.042	0.421
252	M99NK037E	Erdenet	Mogoin gol	granite	99	1.698	-2.965	-1.027	2.915	0.073	0.209	0.924
253	M99NK043	Erdenet	Talbulag	tuff breccia	89	0.421	2.911	-1.523	2.945	-1.351	0.064	0.241
254	M99NK045	Erdenet	Talbulag	silicified rock	98	1.860	-0.157	-1.315	2.759	-0.591	-0.114	-0.028
255	M99NK046E	Erdenet	Talbulag	silicified rock	77	0.639	-0.380	-1.086	-1.693	0.508	0.335	1.080
256	M99NK048E	Erdenet	---	granite	71	-0.323	1.013	1.661	-1.375	2.089	1.230	-0.904
257	M99NK053E	Erdenet	---	quartz+epidote vein	63	0.369	2.479	1.113	1.500	2.899	-0.658	0.905
259	M99NK057N	Erdenet	---	ore	68	-0.900	1.955	1.661	0.222	2.228	0.607	-2.747
260	M99NK060E	Erdenet	Tourmarine	quartz+tourmaline vein	77	0.515	-0.033	-0.723	-1.131	-0.256	0.980	-0.007
261	M99NK064E	Erdenet	---	basalt	59	0.803	2.203	2.314	0.007	1.411	0.054	0.759
262	M99NK068E	Erdenet	Dambatseren	quartz+epidote vein	64	0.334	2.936	1.710	0.684	2.386	0.030	0.463
263	M99NK070E	Erdenet	Dambatseren	dacite	99	1.393	-2.469	-0.600	3.071	-0.785	0.180	-0.336
264	M99NK071E	Erdenet	Dambatseren	quartz vein	93	0.587	0.878	-1.302	2.375	-0.292	0.100	-0.691
265	M99NK075E	Bulgan West	Aguit	breccia	80	0.855	-0.830	-0.110	-1.740	-0.011	0.536	0.618

Table II-4-2 Principal component scores of individual samples in the central north area

Original No.	Sample No.	District	Occurrence	Rock name	Estimated SiO2%	PC1	PC2	PC3	PC4	PC5	PC6	PC7
266	M99NK079F	Bulgan West	Ereen Ikher	breccia	79	1.061	-0.522	-0.698	-2.152	-1.204	0.402	0.327
267	M99NK081F	Bulgan West	Aguit	quartz vein	97	-1.672	-1.237	-0.581	0.734	0.961	0.868	-0.495
269	M99NK084F	---	---	listwaenite	68	2.558	-4.510	10.802	3.391	-1.897	1.696	0.681
270	M99HH003N	Altgana gol	Altgana gol	quartz	79	2.249	-2.365	-0.992	-1.183	-0.645	0.166	-2.263
271	M99HH021F	Erdenet	Danbatseren	dacite~andesite	76	0.555	-0.208	-0.685	-2.010	-0.653	0.497	0.638
272	M99HH025F	Bulgan	Aguit	altered rock	79	-0.346	-0.347	-1.587	-1.728	-0.494	-0.282	-1.431
273	M99HH026F	Bulgan	Aguit	silicified rock	78	-1.408	-0.030	-0.359	-2.080	-0.327	-0.126	-0.626
274	M99HH032F	Bulgan	Jasiin buuts	andesite	69	0.811	0.937	-0.965	-3.127	0.841	0.272	0.754
275	M99HH033F	Bulgan	Jasiin buuts	quartz vein	80	1.051	-0.030	-0.222	-0.411	0.670	0.386	-0.005
276	M99HH034F	Bulgan	Jasiin buuts	dacite or dacitic tuff	78	1.185	-0.482	-1.095	-1.212	-0.323	0.433	0.957
277	M99HH035F	Bulgan	Jasiin buuts	altered rock (andesite?)	81	1.739	-1.759	-1.683	-1.561	0.420	0.470	0.454
278	M99HH036F	Bulgan	---	quartz vein	78	1.106	1.129	2.535	1.053	0.662	0.759	-0.042
279	M99MZ001F	Uubulan	Sairiin hundii	dacite	73	0.643	0.263	-1.268	-3.071	0.263	0.409	0.532
280	M99MZ002F	Uubulan	Gua ulaan uul	silicified rock	74	0.465	-2.601	0.007	-4.175	0.752	-0.094	0.510
281	M99MZ003F	Uubulan	Gua ulaan uul	dacite	76	0.406	-1.043	1.407	-2.874	-0.548	0.036	0.989
282	M99MZ004F	Khujirt	Zost tolgoi	silicified, breccia	79	1.116	-1.539	0.030	-0.620	-0.277	0.801	-1.355
283	M99MZ005F	Khujirt	Zost tolgoi	granite	78	1.305	-0.305	-1.169	-0.667	1.517	0.389	0.950
284	M99MZ006F	Murun South	Donhor bulag	silicified rock	77	1.223	-1.932	-0.819	-2.455	-0.400	-0.526	-0.733
285	M99MZ007F	Murun South	Donhor bulag	silicified rock	82	0.694	-1.320	-1.975	-1.167	0.008	0.126	1.225
286	M99MZ008N	Altgana gol	Altgana gol	quartz veins	100	2.158	-3.463	-0.597	2.915	0.118	0.030	-0.204
287	M99MZ009F	Altgana gol NW	Delger uul	ultra mafic rock	66	2.601	-4.781	11.065	3.183	-2.219	1.134	2.064
288	M99MZ010F	Khokhoo	Hurilt gol	granite	77	0.847	-0.744	-0.492	-1.958	-0.398	0.410	1.441
289	M99MZ011N	Khokhoo	---	Cu ore	91	-7.729	-0.284	0.353	0.816	1.613	2.818	-0.956
290	M99MZ012N	Khokhoo	---	Pb-Cu ore	98	-5.695	-1.926	0.008	0.825	0.072	1.929	0.240
291	M99MZ013F	Khokhoo	---	silicified rock	82	0.160	-1.336	-0.893	-1.469	1.020	1.252	0.498
292	M99MZ014F	South Camp	---	dunite	67	2.041	-5.208	11.160	2.626	-2.543	2.074	1.493
293	M99MZ018F	Erdenet	Khujiriin gol	granodiorite	65	0.436	1.612	2.967	-1.846	-0.041	0.355	0.523
294	M99MZ019F	Erdenet	Khujiriin gol	andesite	71	0.647	1.489	0.943	-1.931	0.184	0.356	-0.061
295	M99MZ020F	Erdenet	Khujiriin gol	monzonite	69	0.201	0.544	0.848	-3.165	-0.265	0.337	0.801
296	M99MZ021F	Erdenet	Khujiriin gol	diorite	61	0.910	2.457	2.687	-0.784	1.132	0.729	0.005
297	M99MZ022F	Erdenet	Talbulag	dacite	65	1.012	2.341	1.967	-1.393	0.808	0.571	0.122
298	M99MZ023F	Erdenet	Talbulag	volcanic rock	80	0.608	-0.517	-0.963	-2.073	-0.199	0.491	0.889
299	M99MZ024F	Erdenet	Davaa	granite	77	0.859	0.474	0.048	-1.504	-0.335	0.362	0.250
300	M99MZ025F	Erdenet	Davaa	granodiorite	58	1.169	3.278	3.368	-0.880	0.586	0.488	0.326
301	M99MZ026F	Erdenet	Tsagaan chuluut	silicified rock	80	0.715	-0.986	-1.533	-1.634	-0.531	0.084	1.127
302	M99MZ027F	Erdenet	Tsagaan chuluut	silica sinter?	77	1.289	-0.880	-2.066	-1.071	-0.645	0.143	0.583
305	M99MZ030F	Erdenet	Tourmaline	granitic rock	81	-0.180	-0.088	-1.054	-0.566	-0.929	0.406	0.507
306	M99MZ031F	Erdenet	Tourmaline	syenite	72	0.922	0.504	0.269	-2.040	-0.174	0.352	0.353
307	M99MZ032F	Erdenet	Tourmaline	breccia	77	0.698	0.092	-0.467	-0.731	-1.124	0.231	-0.588
308	M99MZ033F	Erdenet	Tourmaline	granitic rock	69	-0.361	-0.129	2.004	-1.171	0.523	1.277	0.396
309	M99MZ034F	Erdenet	---	granodiorite	57	0.856	3.307	0.933	0.654	2.462	-0.426	0.609
310	M99MZ035F	Erdenet	---	granitic rock	83	-0.424	0.271	1.303	0.756	-0.222	0.060	1.162
311	M99MZ037	Erdenet	Under	granodiorite	66	0.735	1.752	1.360	-1.098	-0.328	0.033	0.217
312	M99MZ038F	Erdenet	Under	granodiorite	65	0.932	1.820	1.780	-1.148	0.379	0.101	0.162
313	M99MZ040F	Erdenet	Under	quartz porphyry	76	0.941	-0.835	-1.560	-2.097	0.251	0.921	0.272
314	M99MZ049F	Erdenet	Megein gol	silicified rock	80	0.825	-0.419	-1.049	-0.414	0.112	0.309	0.565
315	M99MZ052F	Bulgan West	Urmiin tsgaan nuur	tuff breccia	64	0.945	2.151	1.585	-1.916	0.276	0.423	0.259
316	M99MZ053F	Bulgan West	Urmiin tsgaan nuur	syenite	76	0.786	-0.800	-1.207	-2.582	0.040	0.706	0.456
317	M99MZ060F	Bulgan West	Undrakh	quartz veinlet	84	0.032	0.048	-0.928	-0.516	0.847	0.768	-1.532
318	M99MZ061N	Bulgan	Tsookher mert	quartz vein	96	-9.549	-1.878	-0.709	1.158	-1.248	0.597	1.103
319	M99MZ062N	Bulgan	Tsookher mert	quartz vein	97	-14.830	-2.174	-1.270	1.493	-0.446	-0.081	2.245
320	M99MZ063F	Bulgan	Tsookher mert	granitic rock	81	-7.024	-0.433	-0.057	-1.658	-0.589	1.679	1.131
321	M99MZ064N	Bulgan	Tsookher mert	quartz vein	97	-16.081	-1.997	-1.614	1.217	-0.556	-0.056	2.892
323	M99MZ067N	Bulgan	Khar uul	quartz veinlet	59	-1.324	2.426	2.197	1.777	2.702	-0.252	0.426
324	M99MZ068F	Bulgan	---	quartz veinet	67	0.468	2.532	2.642	0.336	0.854	0.687	0.368
325	M99MZ069F	Bulgan	---	brecciated rock	64	-0.672	3.077	2.691	-0.854	-1.144	0.683	0.694
326	M99MZ070F	Bulgan	---	quartz veinet	70	0.060	2.060	-0.040	-1.072	2.029	-0.671	1.076
327	M99MZ071F	Bulgan	---	andesite	59	0.644	3.625	1.416	1.246	3.104	-0.964	0.920
328	M99MZ072F	Bulgan	---	quartz veinlet	69	0.577	2.636	1.776	1.140	2.288	-0.617	0.717
329	M99MZ073N	Bulgan	---	quartz veinlet	64	-1.660	3.061	2.662	0.361	1.466	1.312	-1.011
331	M99MZ075F	Zaamar West	---	andesite	58	0.262	4.430	3.791	0.360	0.658	-0.096	0.231
332	M99MZ076F	Zaamar West	Mt. Eagle North	tuff	70	0.912	1.786	1.678	0.113	-0.477	-0.196	1.279
333	M99RK001F	Uubulan	Gua ulaan uul	float, tuff breccia	76	0.641	-0.636	-1.525	-2.683	-0.576	0.104	-1.460
334	M99RK002F	Khujirt	Zost tolgoi	dacitic tuff breccia	79	1.502	-1.391	-1.312	0.082	0.582	0.593	0.087
335	M99RK003F	Murun South	Donhor bulag	float, quartz vein	99	1.029	-4.068	-0.410	2.156	0.164	0.468	0.676
336	M99RK004F	Murun South	Donhor bulag	dacitic tuff breccia	81	1.313	-1.455	-0.864	-2.004	-0.549	-0.593	-0.062
337	M99RK005N	Altgana gol	Altgana gol	quartz vein	92	1.559	-1.723	-1.613	0.214	-0.980	-0.686	-2.066
339	M99RK007F	Khokhoo	Quartz	float, quartz vein	99	1.287	-4.724	0.712	1.937	0.569	0.550	0.468
340	M99RK008	Khokhoo	---	quartz vein	97	1.504	-2.497	1.141	1.693	-0.089	0.780	1.085
341	M99RK009F	Khokhoo	---	quartz vein	99	1.806	-3.194	-0.358	1.821	-0.334	0.921	1.017
342	M99RK010F	Khokhoo	---	float, granite?	78	0.876	-0.899	-0.193	-1.233	1.168	0.556	1.059
343	M99RK011F	Khokhoo	---	quartz vein?	80	1.077	0.305	1.531	-0.042	0.171	0.757	1.171
344	M99RK012F	Khokhoo	Quartz	float, quartz vein	99	1.588	-3.779	-0.311	2.401	-0.261	-0.044	1.199
345	M99RK013F	Khokhoo	Quartz	quartz vein	84	0.302	-1.719	-1.828	2.039	3.720	-0.415	1.580
346	M99RK014F	Khokhoo	Quartz	limestone	51	-0.668	-3.930	1.709	1.353	5.936	-0.479	2.227
348	M99RK016F	Khokhoo	Quartz	limestone	51	0.880	-3.709	1.442	2.350	5.566	-0.778	1.886
349	M99RK017F	South Camp	---	quartz vein	95	-0.457	-2.898	-1.090	1.411	1.128	0.957	0.687
350	M99RK018F	South Camp	---	float, quartz vein	77	0.441	-0.158	-0.356	2.512	4.157	-0.595	1.146
351	M99RK019F	South Camp	---	quartz vein	76	0.798	-0.835	-1.277	2.929	5.103	-0.967	1.309
352	M99RK022F	Erdenet	Khujiriin gol	float, granite	70	0.311	1.614	1.851	-1.392	-0.366	0.074	0.839
353	M99RK023F	Erdenet	Khujiriin gol	quartz vein	91	0.148	-2.179	0.193	-0.614	0.722	1.040	0.382
354	M99RK024F	Erdenet	---	silicified rock(granite)	61	0.668	2.592	1.170	0.996	3.685	-0.768	0.432
356	M99RK027F	Erdenet	---	aplite	81	1.155	-0.703	-1.743	-0.743	1.289	1.081	-0.618
358	M99RK029F	Erdenet	Central	granite	81	1.938	1.891	-2.853	1.404	0.340	0.496	-1.309
359	M99RK031N	Erdenet	Central	granite	73	0.319	1.018	0.094	-1.337	1.209	0.058	-3.151

Table II-4-2 Principal component scores of individual samples in the central north area

Original No.	Sample No.	District	Occurrence	Rock name	Estimated SiO2%	PC1	PC2	PC3	PC4	PC5	PC6	PC7
360	M99RK032N	Erdenet	Central	diorite	62	-0.380	1.866	1.187	-1.818	2.227	0.422	-1.800
361	M99RK033F	Erdenet	---	aplite	89	1.239	-2.194	-1.397	0.098	0.118	0.270	0.474
362	M99RK034F	Erdenet	---	granite	76	0.930	0.421	0.681	-0.649	1.051	0.933	0.129
363	M99RK037F	Erdenet	---	quartz vein	91	1.372	-2.870	-0.639	0.490	0.652	0.758	0.441
364	M99RK039N	Erdenet	Shand	granite	72	-0.860	-0.091	1.583	-2.144	0.626	1.132	-3.329
365	M99RK041	Erdenet	---	float, silicified rock	84	0.393	-1.008	0.014	2.071	2.407	0.397	-0.177
366	M99RK042F	Erdenet	---	granite	77	0.890	0.743	-1.208	-0.054	1.864	0.850	-0.227
367	M99RK043F	Erdenet	---	aplite	78	0.805	-3.767	-1.256	-2.425	1.103	0.629	0.848
368	M99RK045F	Bulgan West	Urmiin tsgaan nuur	lapilli tuff	69	0.862	1.275	0.450	-2.620	0.525	0.411	0.252
369	M99RK046F	Bulgan West	Urmiin tsgaan nuur	lapilli tuff	69	0.990	0.679	0.054	-2.869	0.932	0.663	0.027
370	M99RK047F	Bulgan West	Urmiin tsgaan nuur	lapilli tuff	76	0.795	-1.024	-0.887	-2.654	0.850	0.559	0.394
371	M99RK048F	Bulgan West	Ereen ikher	silicified rock	76	0.672	-0.730	-0.562	-2.461	-0.120	0.345	1.325
372	M99RK049F	Bulgan West	Ereen ikher	lapilli tuff	78	0.918	-1.191	-1.036	-2.557	0.414	0.503	1.111
373	M99RK050F	Bulgan West	Ereen ikher	lapilli tuff	76	0.540	-0.240	-0.974	-2.553	-1.056	-0.190	0.963
374	M99RK051F	Bulgan West	Ereen ikher	lapilli tuff	73	-0.306	0.079	-1.052	-2.716	-2.737	-0.562	0.696
375	M99RK052	Bulgan West	Zaiian	granite	75	0.435	0.307	-0.015	-1.969	0.511	0.971	-0.997
378	M99RK055N	Bulgan West	Undrakh	granite	83	-0.219	-1.356	-0.487	-1.055	0.106	0.586	-3.082
379	M99RK057N	Bulgan West	Undrakh	granite	79	0.288	-1.355	-1.605	-2.280	0.985	1.176	-0.942
380	M99RK058F	Bulgan	Jasiin buuts	dacite?	97	1.973	-2.047	-1.068	2.202	-0.475	0.475	-0.984
381	M99RK059F	Bulgan	Jasiin buuts	dacite?	80	1.660	-1.489	-1.393	-0.740	0.073	0.739	0.058
382	M99RK060F	Bulgan	Jasiin buuts	dacite?	77	0.659	1.133	-0.980	-1.057	0.665	-0.080	-0.403
383	M99RK061F	Bulgan	Jasiin buuts	dacitic tuff	80	0.668	-0.346	-1.432	-1.448	-0.179	0.634	0.270
384	M99RK062	Bulgan	Jasiin buuts	silicified rock	95	1.240	-0.893	-1.209	1.949	0.058	0.841	0.314
385	M99RK063F	Bulgan	---	silicified rock	53	0.237	3.309	1.486	0.992	3.166	-1.243	1.022
386	M99RK064F	Bulgan	---	andesite	81	0.521	0.161	-0.700	-0.673	0.661	0.770	0.050
387	M99RK065F	Bulgan	---	silicified rock	87	0.666	-1.349	-0.025	-0.342	0.197	0.670	0.687
388	M99RK066F	Bulgan	---	float, epidote vein	64	0.491	3.787	1.433	1.300	2.377	-0.749	0.896
390	M99RK068N	Bulgan	---	epidote vein	66	-0.992	2.761	0.834	1.437	3.336	-0.318	-1.110
391	M99RK069F	Bulgan	Mt. Zain gobaav	white altered rock	81	0.078	3.159	-3.097	2.044	0.347	0.273	0.147
392	M99RK070F	Bulgan	Mt. Zain gobaav	white altered rock	78	-0.477	2.627	-1.982	1.668	-0.872	0.481	0.752
393	M99RK071F	Bulgan	Mt. Zain gobaav	altered rock	73	-0.303	3.162	1.462	1.723	-2.187	-0.174	1.330
394	M99RK072F	Bulgan	Mt. Zain gobaav	altered rock	65	0.603	2.410	2.493	2.864	-2.539	-0.477	-0.619
395	M99RK073F	Bulgan	Mt. Zain gobaav	altered rock	92	0.074	2.817	-2.311	2.262	-0.005	0.470	0.467
396	M99RK074F	Bulgan	Mt. Zain gobaav	white altered rock	85	-0.516	3.527	-2.031	2.312	-1.325	0.018	1.196
398	M99RK076N	Bulgan	---	andesite	54	-1.225	2.391	2.505	1.864	4.535	-1.250	-0.986
399	M99RK077F	Bulgan	Mt. Zain gobaav	float, white altered rock	88	-1.493	3.474	-2.332	2.672	-0.727	0.832	0.762
400	M99RK078F	Bulgan	Mt. Zain gobaav	andesite	71	0.092	2.424	2.286	0.038	0.578	0.993	-1.314

Table II-4-3 Summary of geochemical PCA results in the central north area

District	Mineral occurrence	Principal components	Type
Erdenet	Tsagaan chuluut - Talbulag	29 samples in a total of 57 samples show positive relationship with PC2. Two samples and one sample show positive relationship with PC1 and PC7 respectively.	A
Bulgan	Mt.Zain Gobaav	All of eight samples in a total show positive relationship with PC2. Two of them also show positive relationship with PC1 or PC7.	A
Bulgan	Bulgan	Eleven samples in a total of 13 samples show positive relationship with PC2. Three of them show positive relationship with PC1 and/or	A
Erdenet	Erdenet NW ore body and its vicinity	Six samples in a total of 14 samples show positive relationship with PC2. One of them, ore sample collected from the Erdenet NW pit also shows positive relationship with PC7.	A
Erdenet	Khujiriin gol	Seven samples in a total of 11 samples show positive relationship with PC2 and one sample shows positive relationship with PC1.	A
Erdenet	Mogoin gol	Eight samples in a total of 19 samples show positive relationship with PC2 and one sample shows positive relationship with PC1 and PC7.	A
Zelter	Gatsuunkhan	Four samples in a total of five samples show positive relationship with PC2. The other one sample shows no relationship with PC1, PC2 or PC7.	A
Erdenet	Under	Four samples in a total of 10 samples show positive relationship with PC2. The other six samples show no relationship with PC1, PC2 or PC7.	A
Erdenet	Davaa	One sample in a total of two samples shows positive relationship with PC2.	a
Bulgan West	Urmiin tsagaan nuur	Two samples in a total of five samples show positive relationship with PC2.	a
Bulgan NW	Bulgan NW	Two samples in a total of five samples show positive relationship with PC2.	a
Bulgan	Jasiin buuts	Only one sample in a total of nine samples show positive relationship with PC2. The other eight samples don't show any positive relationship with PC1, PC2 nor PC7.	a
Tosontsengel	Zost uul	All of five samples in a total show positive relationship with PC7. One of them also show positive relationship with PC2.	B
Erdenet	Danbatseren	Six samples in a total of 19 samples show positive relationship with PC7 or PC2. The other 13 samples show no positive relationship with PC1, PC2 or PC7.	B
Bulgan West	Undrakh	Eight samples in a total of 10 samples show positive relationship with PC7.	B
Erdenet	Erdenet Central ore body and its	All of three samples in a total show positive relationship with PC2 and PC7.	B
Erdenet	SAR139	All of two samples in a total show positive relationship with PC7. One of them also shows positive relationship with PC2.	b
Khujirt	Zost tolgoi	Two samples in a total pf six samples show positive relationship with PC7 or PC2. The other four samples show no positive relationship with PC1, PC2 or PC7.	b
Uubulan	Gua ulaan uul	Two samples in a total of four samples show positive relationship with PC7.	b
Altgana gol	Altgana gol	Two samples in a total of five samples show positive relationship with PC7. The other three samples show no positive relationship with PC1, PC2 or PC7.	b
Tosontsengel	Quartzite	Only one sample in a total of seven samples show positive relationship with PC7. The other six samples show no positive relationship with PC1,PC2 or PC7.	b
Bulgan SW	Oyuut khonkhor	22 samples in a total of 26 samples show positive relationship with PC1. Ten samples of them also show positive relationship with PC2. One sample of them also shows positive relationship with PC7. The other four samples show positive relationship with only PC7.	C
Bulgan	Tsookher mert	Eight samples in a total of 12 samples show positive relationship with PC1.	C
Erdenet	Zhuukhiin gol	One sample in a total of seven samples shows positive relationship with PC1 and PC7, one sample shows positive relationship with PC1 and other one sample shows positive relationship with PC2. The other four samples show no positive relationship with PC1, PC2 or PC7.	c
Tsagaan uul	Tsagaan uul	Two samples in a total of four samples show positive relationship with PC1. Only one sample shows positive relationship with PC2.	c
Tsagaan uul	Khunkh tsakhir	Three samples in a total of four samples show positive relationship with PC1. Only one sample shows positive relationship with PC2.	c
Bulgan West	Burged khyr	One sample in a total of seven samples shows positive relationship with PC1 and other one sample shows positive relationship with PC2. The other five samples show no positive relationship with PC1, PC2, or PC7.	c
Zaamar	Sudal N177	One sample in a total of six samples shows positive relationship with PC1 and PC7, and other one sample shows positive relationship with PC2. The other four samples show no positive relationship with PC1, PC2, or PC7.	c
Khonkhoo	Khonkhoo	Two samples in a total of nine samples show positive relationship with PC1 and other one sample shows positive relationship with PC2. The other six samples show no positive relationship with PC1, PC2, or PC7.	c
Tariat	Terkhiin tsagaan nuur	Only one sample in a total of four samples shows positive relationship with PC1 and the other three sample show no positive relationship with PC1, PC2, or PC7.	c
Tavt	Tavt	Two samples in a total of five samples show positive relationship with PC1 and PC7. One sample shows positive relationship with PC1, PC2 and PC7. One sample and the other one sample show positive relationship with only PC1 and only PC7.	D
Tavt	Teshig No.2	One sample in a total of two samples show positive relationship with PC2 and PC7. The other one sample shows positive relationship with PC1, PC2 and PC7.	d
Murun West	Tsagaan tolgoi	Three samples in a total of six samples show positive relationship with PC7 and other two samples show positive relationship with PC1. No sample show positive relationship with PC2.	d
Tosontsengel	Naranbulag	Only one sample in a total of four samples shows positive relationship with PC1 and PC7. The other three sample show no positive relationship with PC1, PC2, or PC7.	d
Erdenet	Tourmarine	All five samples show no positive relationship with PC1, PC2 or PC7.	X
Bulgan West	Ereen ikher	All five samples show no positive relationship with PC1, PC2 or PC7.	X
Tosontsengel	Davaa	All four samples show no positive relationship with PC1, PC2 or PC7.	X
Murun South	Donhor bulag	All seven samples show no positive relationship with PC1, PC2 or PC7.	X
Murun West	Ulaan nuur	All three samples show no positive relationship with PC1, PC2 or PC7.	X
Tsagaan uul	Ulaan zavsar	All three samples show no positive relationship with PC1, PC2 or PC7.	X
Tsagaan uul	Gurvan buudal uul	All three samples show no positive relationship with PC1, PC2 or PC7.	X
Tsagaan uul	Deed ulaan tolgoi	All five samples show no positive relationship with PC1, PC2 or PC7.	X
Khonkhoo	Quartz	All five samples show no positive relationship with PC1, PC2 or PC7.	X
South Camp	South Camp	All four samples show no positive relationship with PC1, PC2 or PC7.	X

Table II-4-4 Alteration minerals of samples used for the multivariate analysis

Group	Samples (multivariate analysis)	Sample (X-ray)	%	Sericite	%	Alunite+ Kaolin	%	Alunite	%	Kaolin	%	Andalusite	%	Pyrite	%
PC2	105	42	40	18	43	8	19	5	12	14	33	4	10	7	17
PC2-	69	19	28	12	63	0	0	0	0	1	5	0	0	2	11
PC7	38	13	34	7	54	0	0	0	0	0	0	0	0	1	8
PC7-	15	7	47	4	57	0	0	0	0	1	14	1	14	1	14
PC1	44	13	30	13	100	0	0	1	8	3	23	0	0	2	15
PC1-	33	10	30	6	60	1	10	0	0	0	0	0	0	0	0
PC1,7	9	2	22	2	100	0	0	0	0	1	50	0	0	0	0
PC1,7-	2	0	0	---	---	---	---	---	---	---	---	---	---	---	---
X	66	33	50	13	39	4	12	5	15	5	15	2	6	1	3

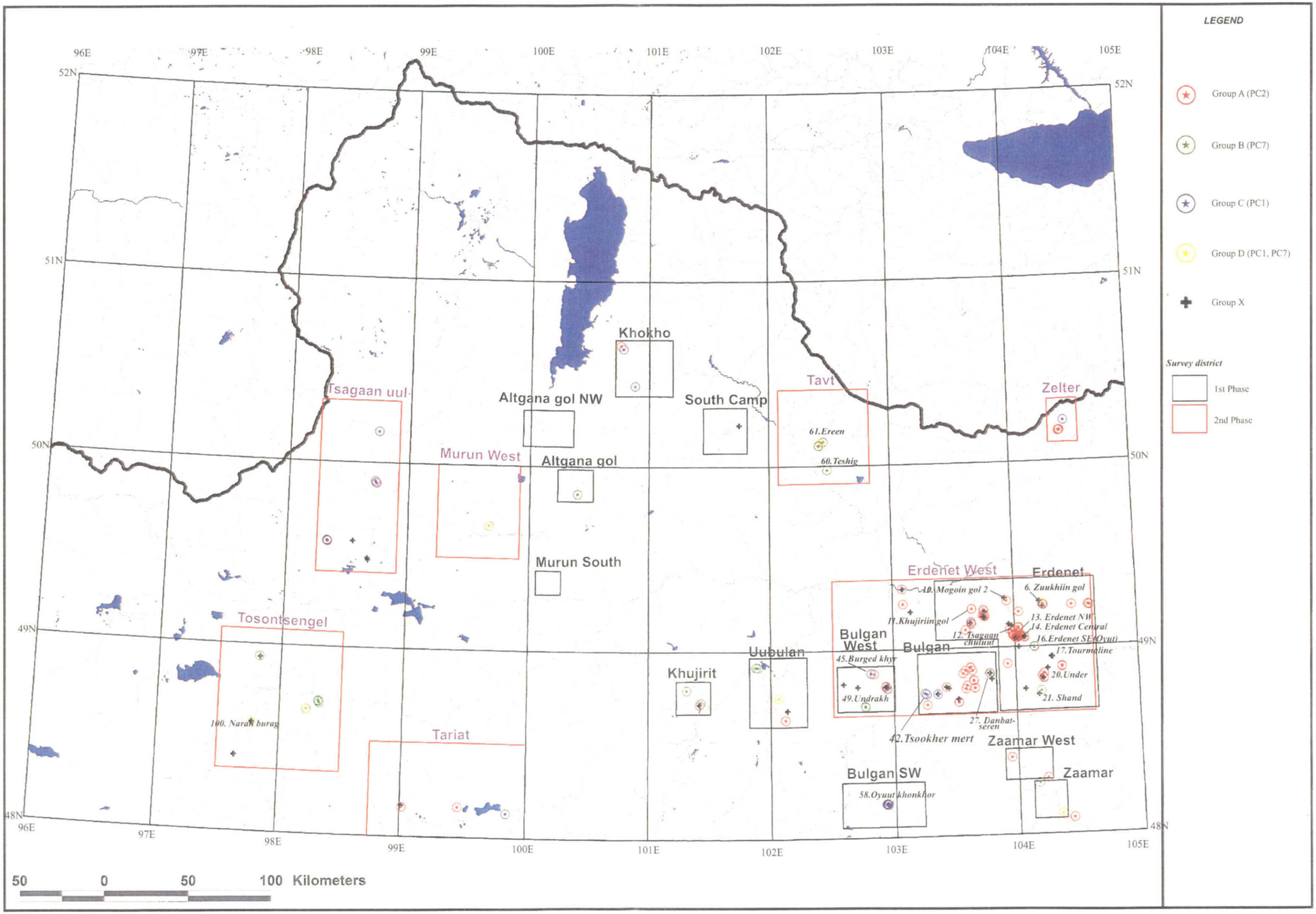

Fig. II-4-2 Results of geochemical principal components analysis

4.4 Conclusion

Among the mineral occurrences of the 5 groups mentioned above, those of the B, C and D groups are considered to be able to assess the mineralization more or less from the showings on the surface. The reason is that mineralizaion is recognized on the surface and/or at the comparatively shallow depths.

With regard to the X-group, detail has not yet been clear, since the number of the data is too small. However, as to the porphyry type copper/molybdenum occurrences of this group, it is considered that the major parts of the ore bodies might have already been eroded out and only the barren roots might crop out at present.

With regard to the mineral occurrences of the A-group, on the other hand, blind deposits of the porphyry type copper/molybdenum might be expected, though the depths are unknown. Especially in the Tsagaan chuluut–Talbulag district, porphyry type copper/molybdenum deposits similar to the Erdenet deposit might be expected at depths, although no showings such as oxide copper are observed on the surface. The reasons are as follows: The district is situated on the northwestern extension of the Erdenet deposit group, in which the Erdenet SE, Erdenet Central and Erdenet NW deposits are aligned from the south towards the north. The depths of the known deposits tend to become deeper towards the north and alteration occurs widely (actually the exposure of bed rocks is poor, and only silicified rocks on the ridges and their frost shattered debris on the flanks seem to cover the surface).

4.5 Petrochemical characteristics of granitic and volcanic rocks

4.5.1 Granitic rocks

The samples of granitic rocks were petrochemically studied on their principal and minor compositions, as well as the rare-earth elements (REE). For the study, unaltered and weakly altered samples were selected by microscopy from the chemically analyzed samples (Appendix Table A-22). Here, the weakly altered means such an alteration as accompanying a small amount of chlorite.

Granitic rocks were classified into those of the early to middle Paleozoic (Cambrian to Carboniferous) and those of the later stage (Permian to Triassic) referring to the 1:1000,000 geologic map and existing data. Particularly as to the granitic rocks of the late Paleozoic, those of the Selenge complex and the Erdenet comples were separately treated respectively, when they were distinguished.

The results of the Norm calculation are shown in the Q-A-P (Quartz-Alkali feldspar-

Plagioclase) diagram (Figure II-4-3). In this diagram, granitic rocks from the investigated area are plotted in the fields of monzodiorite, granomonzonite, tonalite, granodiorite, and monzogranite. Plots are particularly concentrated in the fields ranging from granodiorite to monzogranite.

In the diagrams of Rb-(Y+Nb) (Figure II-4-4) , Rb-(Yb+Ta) (Figure II-4-5) , Ta-Yb (Figure II-4-6) and Nb-Y (Figure II-4-7) by Pearce et al. (1984) , all the plots fall within the volcanic arc granite field, except a biotite granite(M00HH119) sample collected in the Khunkh tsakhir mineral occurrence . This implies that these granitic rocks are the products of the igneous activity of the island arc type related with the subduction of the plate.

The plots in the chondrite normalized diagram of Ce/Yb-Yb by Ogasawara (1989) are shown in Figure II-4-8. For the normalization, the recommended values by Boynton (1984) were used. This diagram shows the chondrite normalized pattern of the Ce/Yb using normalized values of light rare earth (LREE) Ce and heavy rare earth (HREE) Yb, as well as the relative degree of concentration and decrease of HREE by normalized Yb. Besides the data of the present study, normalized values of the protomantle, MORB, A-type granites, continental crust, tonalite and trondhjemite by Orasawara(1989) are also plotted in the same diagram.

The partition coefficients of REE between the magma melt and major rock forming minerals of igneous rocks are less than 1, so that REE tend to concentrate in magma by the differentiation crystallization. Moreover, the melt becomes relatively enriched in LREE by it, as major rock forming minerals have larger coefficient with HREE. Therefore, it can generally be regarded that the samples plotted at the top left in Figure II-4-8 are more differentiated.

REE in granitic rocks are mainly contained in accessory minerals such as allanite, zircon, apatite and so forth and are contained less in biotite, plagioclase and potash feldspar. In case that plural granitic bodies are generated from melt of magma , the earlier formed body is relatively rich in allanite, shpene, zircon and apatite, while the later formed one is poor in them but rich in plagioclase and potash feldspar. Therefore, a granitic body generated from more differentiated magma is poor in REE but relatively rich in LREE(La to Sm) , showing a right down chondrite normalized pattern and is plotted at the top left in Figure II-4-8.

Granitic rocks from the Tourmaline, Under and Nomgon mineral occurrences in this study are plotted in the same field to the continental crust in the diagram. Therefore, it can be understood that they were formed from the undifferentiated magma generated in the continental crust. However, most of the granitic rocks in the investigated area show a tendency that they were more differentiated than the granitic rocks in the continental crust. Especially the granitic rocks in the Oyut (Erdenet SE) ,Central, Ulannuur and Ereen (Tavt) districts show that they were generated from the magma similar to trondjhemite or more differentiated. It is said that the formation of a the porphyry type deposit is related with differentiated granitic rocks with relatively poor HREE (Ogasawaea, 1989; after Gromet and Silver, 1983) and this is well

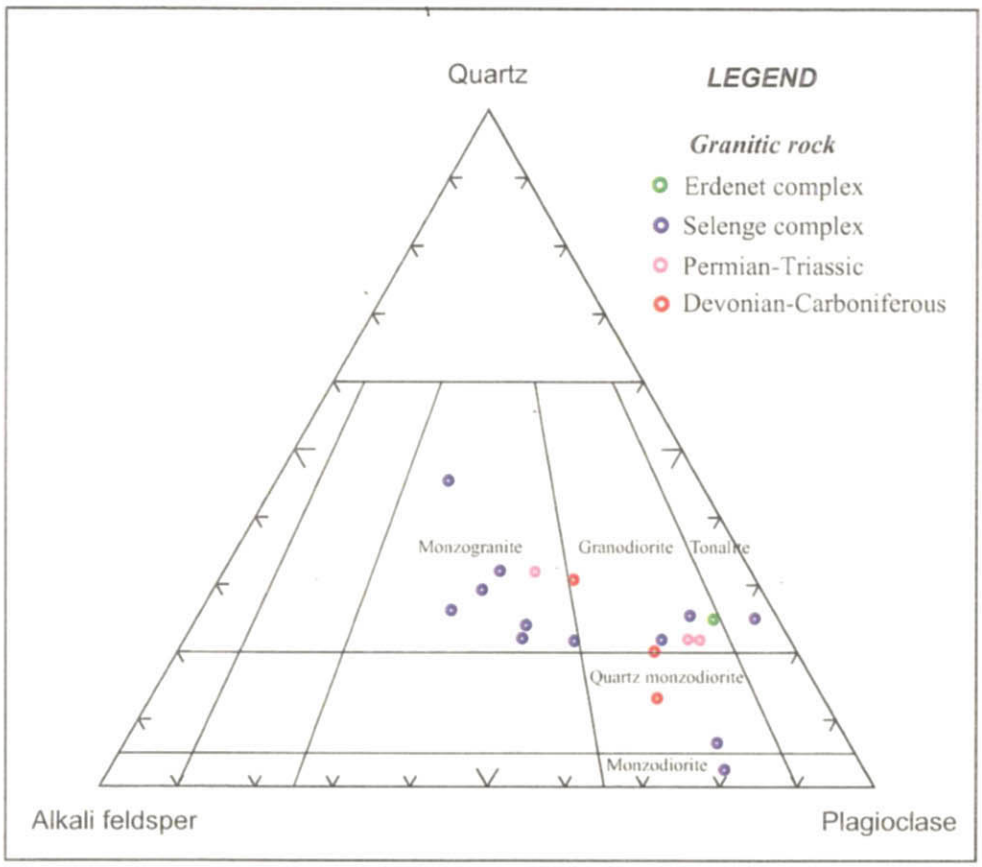

Fig. II-4-3 Quartz - Alkali feldsper - Plagioclase diagram

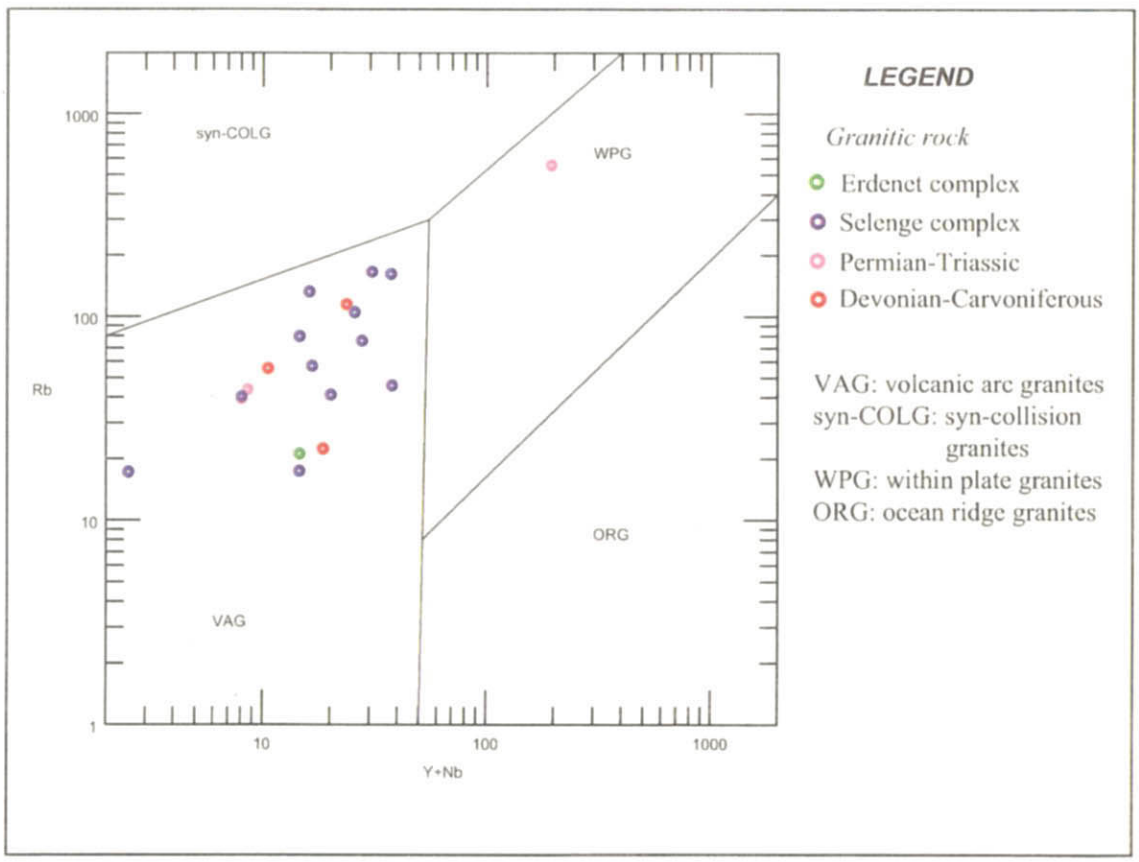

Fig. II-4-4 Rb - (Y+Nb) diagram (Pearce et al., 1984)

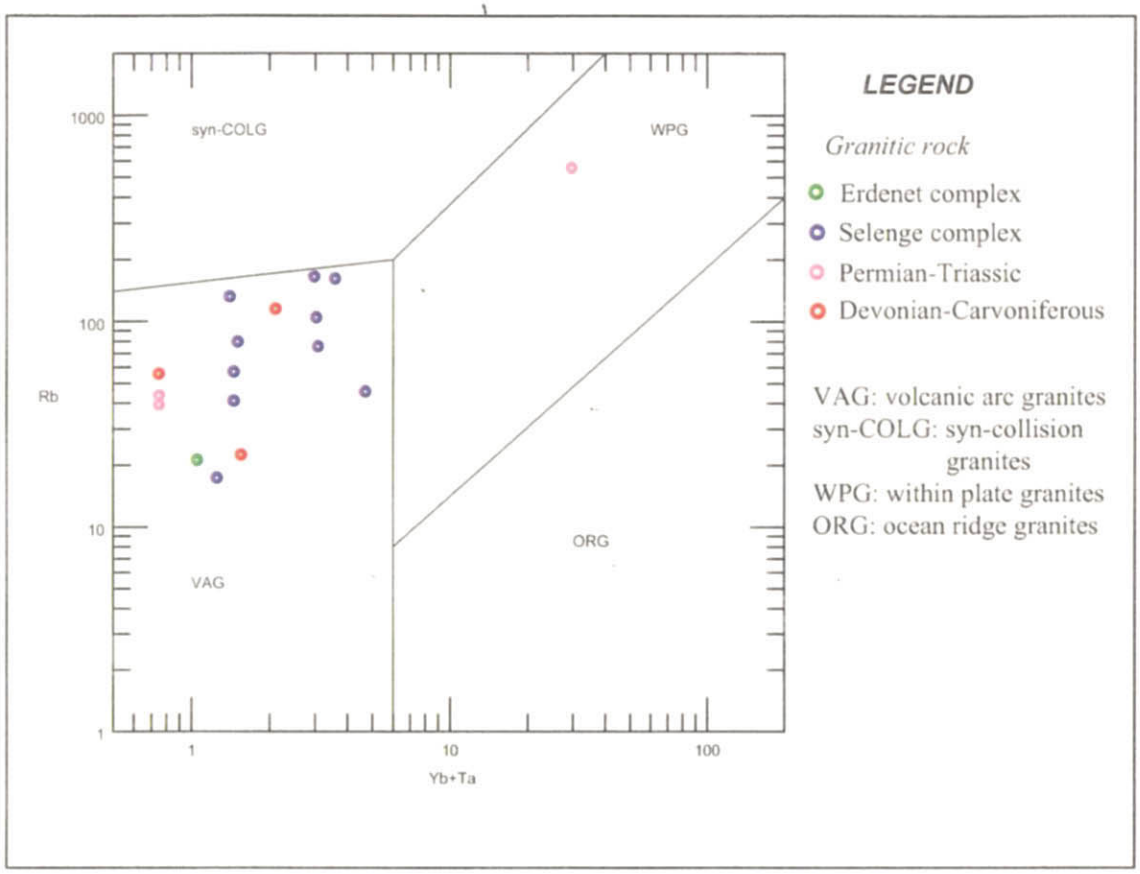

Fig. II-4-5 Rb - (Yb+Ta) diagram (Pearce et al., 1984)

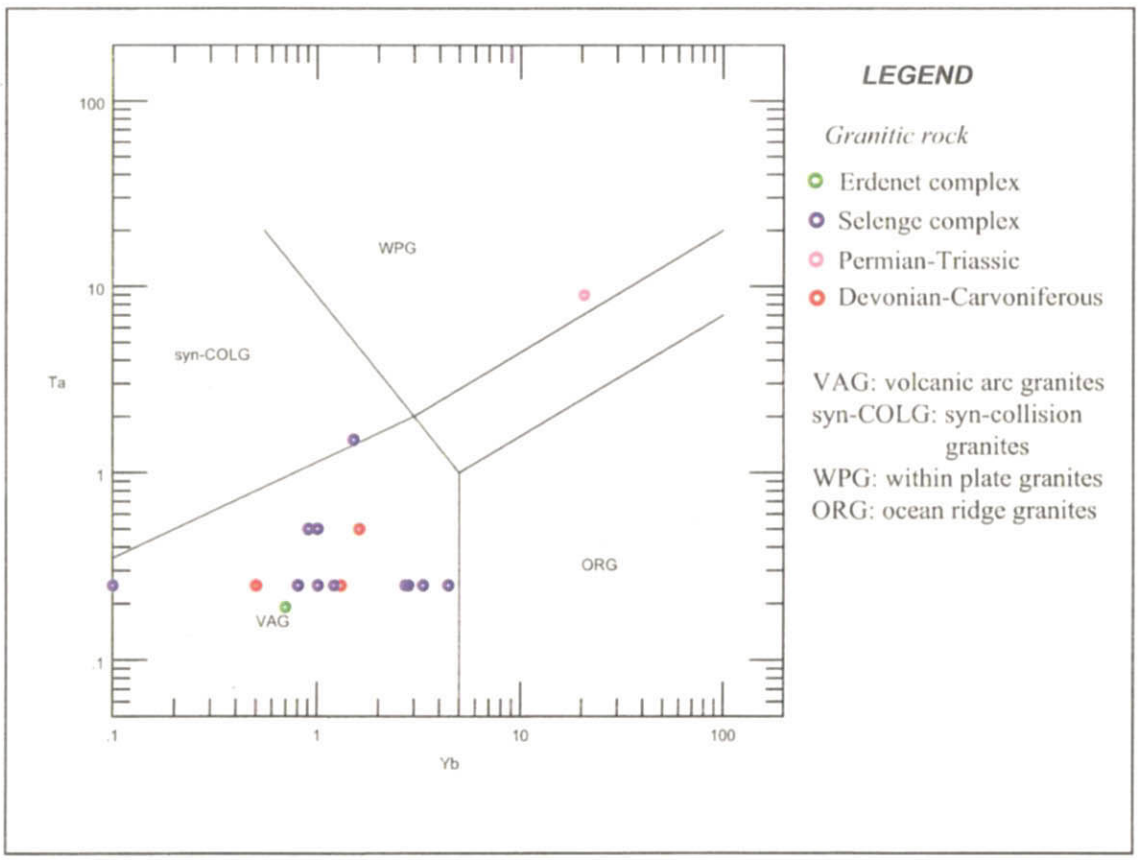

Fig. II-4-6 Ta - Yb diagram (Pearce et al., 1984)

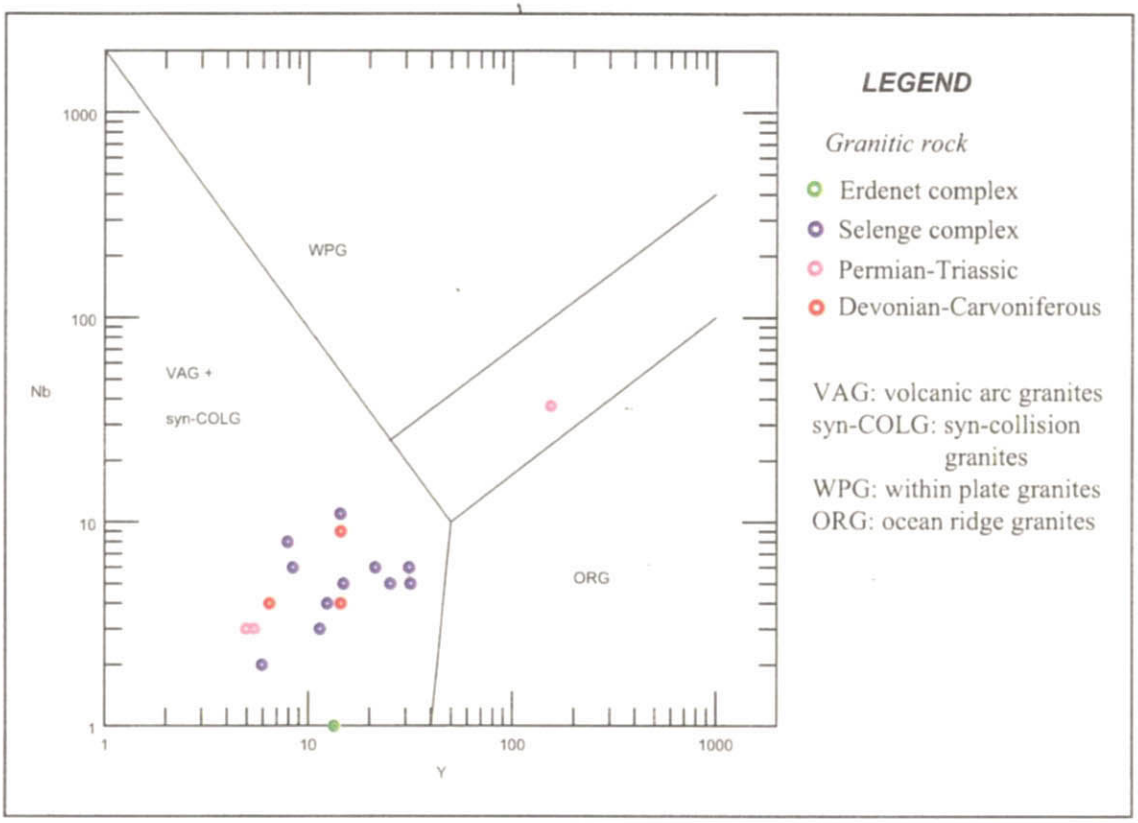

Fig. II-4-7 Nb - Y diagram (Pearce et al., 1984)

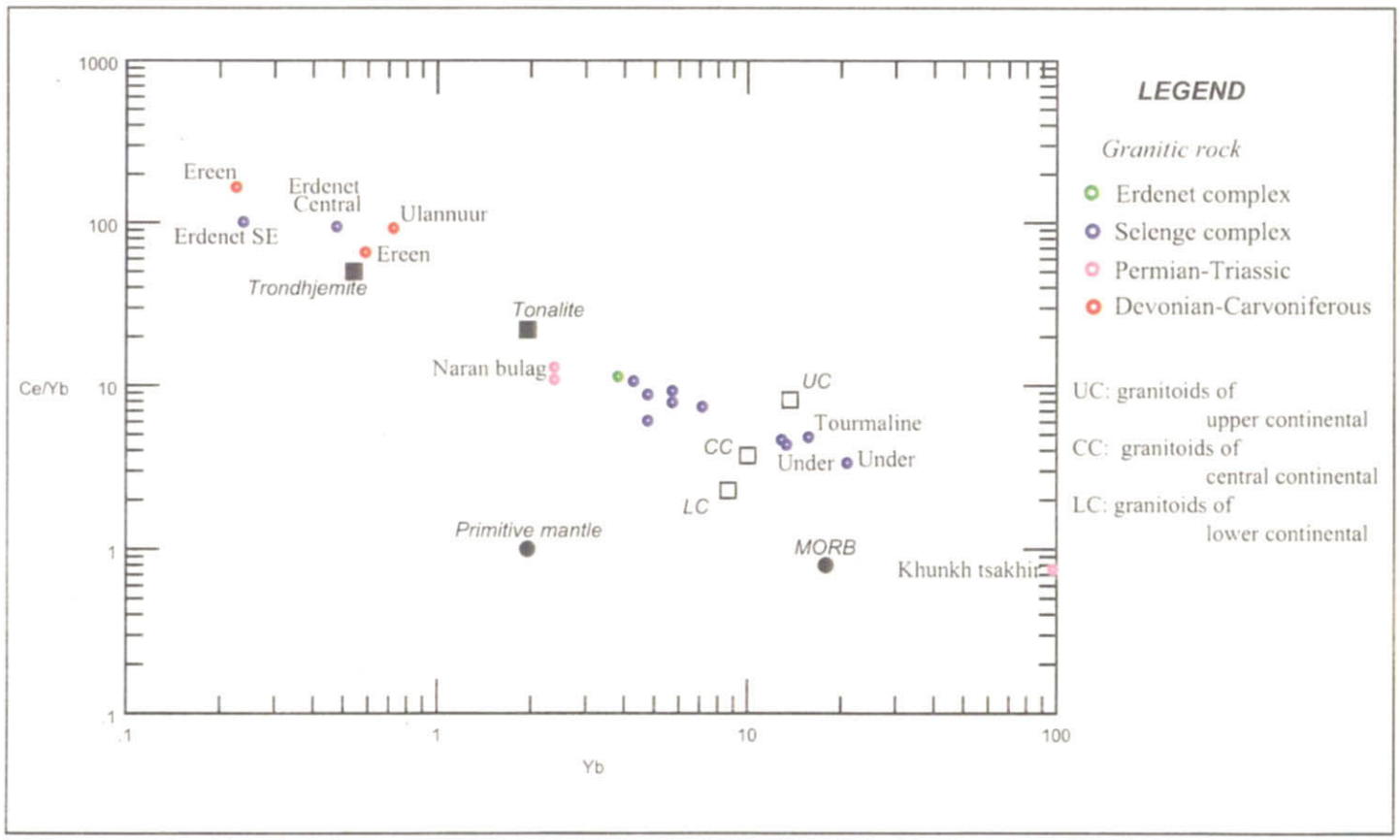

Fig. II-4-8 Chondrite normalized Ce/Yb - Yb diagram

conformable with the results mentioned above.

From the findings on minor elements and REE mentioned above, it has become clear that granitic rocks in the investigated area, especially those in the Erdenet West district have characteristic features of the island arc type which were related with the subduction of the plate. Moreover, it has also been understood that most of granitic rocks in the investigated area, except those in the Tourmaline, Under and Nomgon mineral occuurences, have more differentiated features compared with the granitic rocks in the continental crust by Ogasawara (1989). Particularly granitic rocks in the Oyut (Erdenet SE) ,Central, Ulannuur, Naranbulag and Ereen (Tavt) districts were generated from by far the more differentiated magma, showing the relationship between this and mineralization.

4.5.2 Volcanic rocks

Petrochemical studies on principal and minor compositions as well as REE were carried out for the volcanic rocks in the investigated area. All the samples tested were collected from the Erdenet West district and range from basalt to andesite. For the study, unaltered to weakly altered samples were selected from chemically analyzed ones based on microscopy using the similar criteria to granitic rocks (Appendix Table A-23).

In the A-F-M (Alkali (Na_2O+K_2O)-FeO*(total Fe)-MgO)(Figure II-4-9) diagram, all the samples are plotted in the field of alkalic rocks.

In the FeO*/MgO-SiO_2 (Figure II-4-10) diagram, one of the Harker diagrams, samples are plotted around the boundary between calc –alkalic and tholeiitic rock fields. On the other hand, in the Alkali (Na_2O+K_2O)-SiO_2 (Figure II-4-11) diagram, they are plotted around the boundary between the sub-alkalic and alkalic rock fields, and further, based on the classification by Le Bas et al. (19860, they are plotted in the fields of basaltic trachyandesite, trachyandesite and trachyte .

In the Zr/TiO2-Nd/Y(Figure II-4-12) diagram, samples are plotted in the fields of andesite, dacite and rhyolite near the boundary with trachyandesite.

From these findings mentioned above, it has become clear that the volcanic rocks in the Erdenet West district are rich in alkalic compositions, showing slightly alkalic features petrochemically, though the number of samples is small.

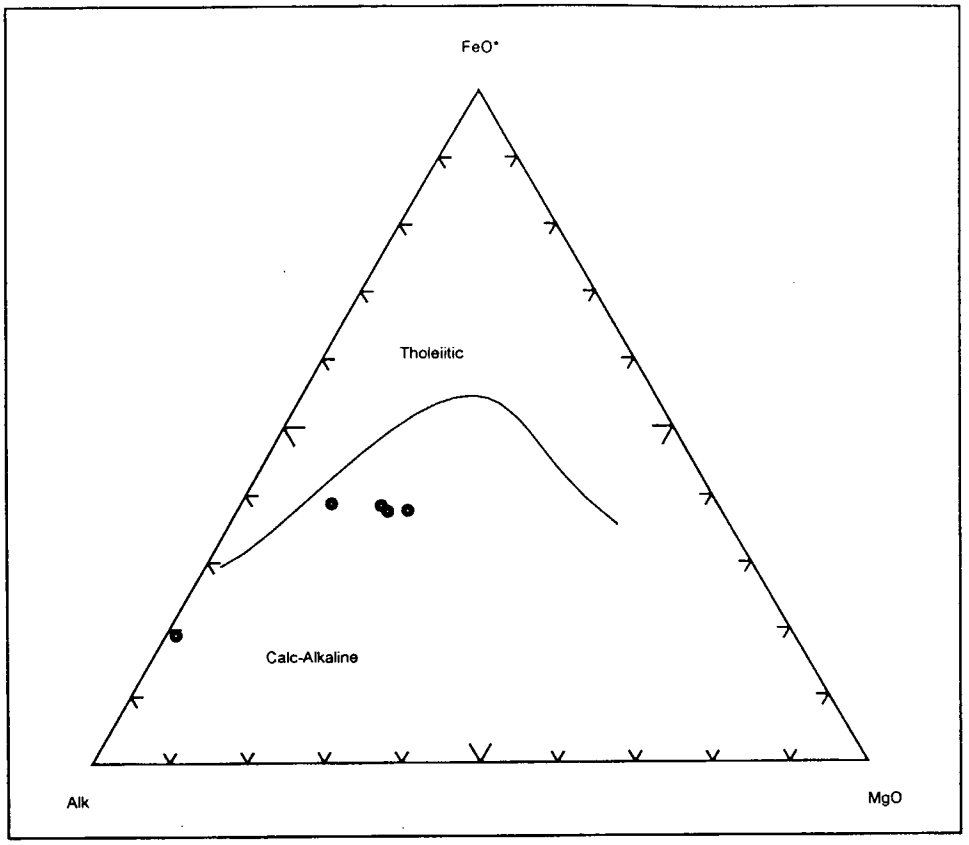

Fig. II-4-9 Alkali (Na2O+K2O) - FeO* - MgO diagram

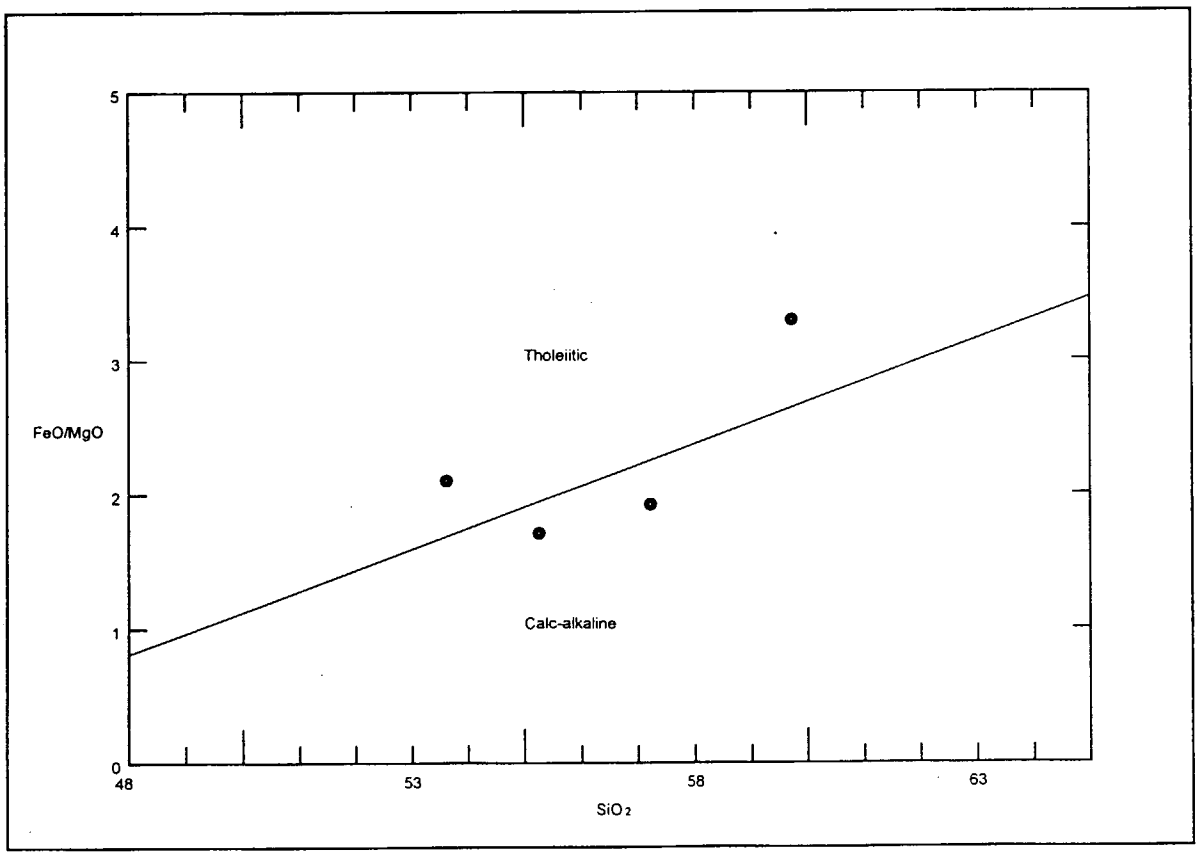

Fig. II-4-10 FeO*/MgO - SiO2 diagram

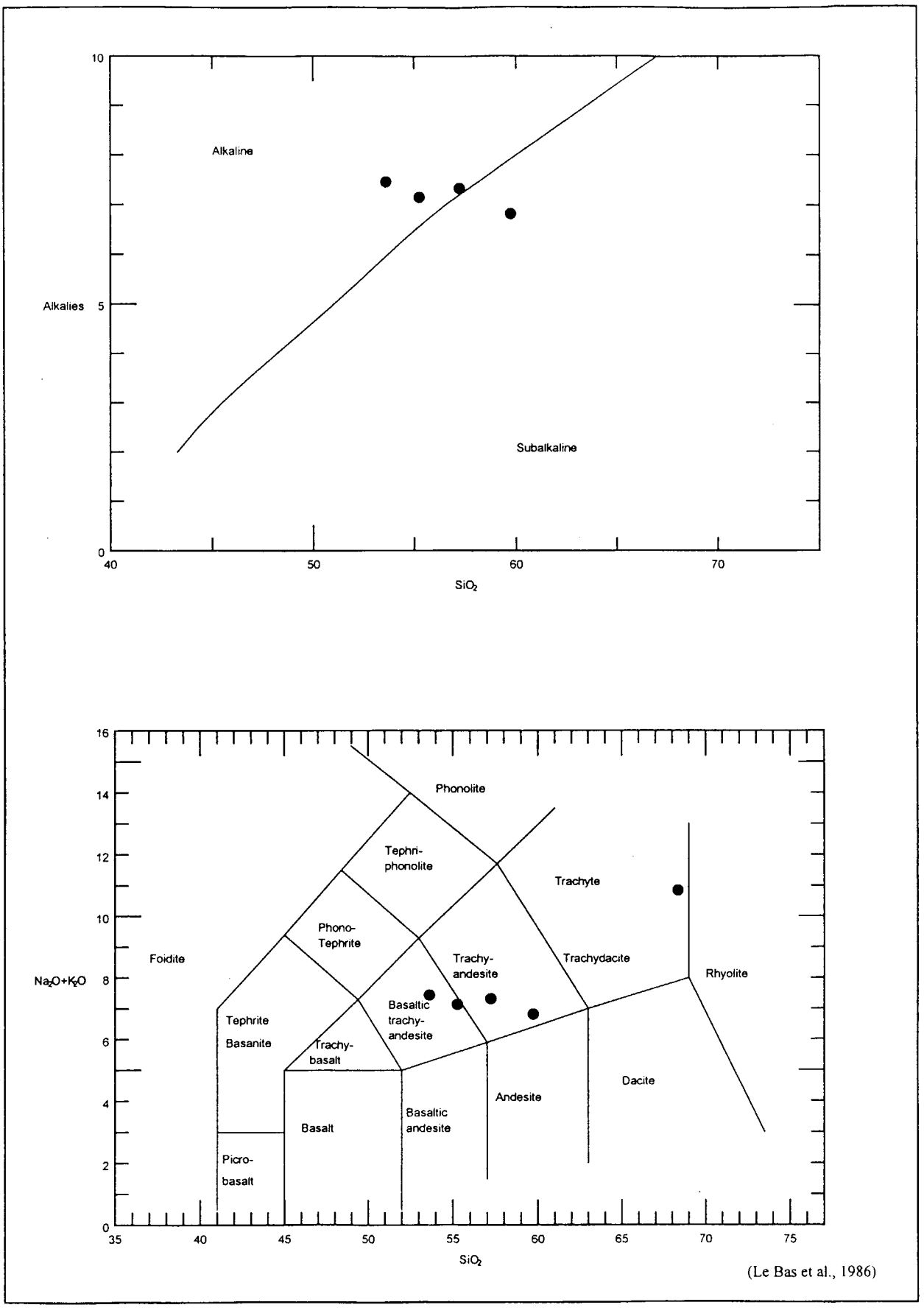

Fig. II-4-11 (Na2O+K2O) - SiO2 diagram

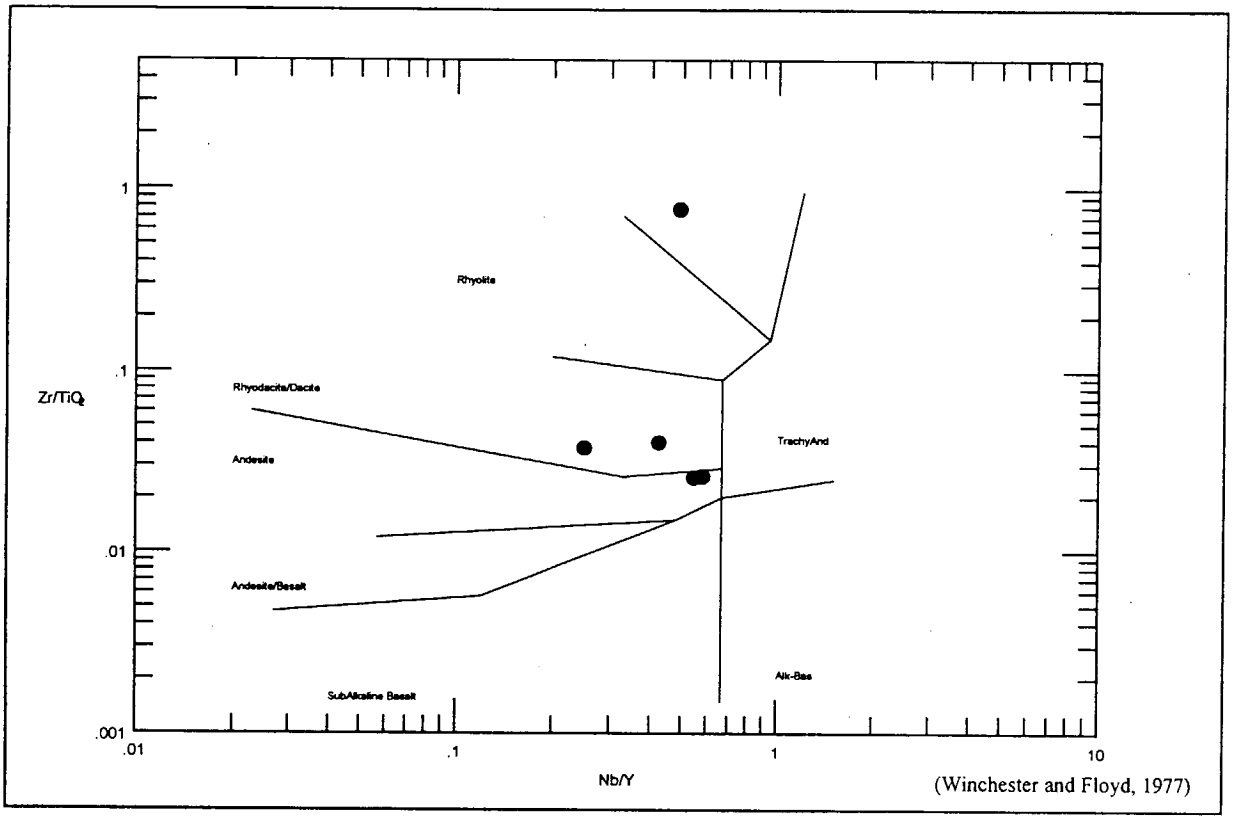

Fig. II-4-12 Zr/TiO2 - Nd/Y diagram

Chapter 5 Discussion

5.1 Geological structure and mineralization

In studying the genesis of the ore deposit, it is important to understand the development of the geological structure of the area concerned. However, the development of the geological structure in Mongolia has not been clarified in detail so far, and there is different opinions to discuss. For instance, the geologic bodies are sometimes classified into the Terrane (Unit), but, at present, there are different opinions of different researchers. Therefore, we have estimated the prospective ore deposits within the survey area in terms of the kinds and types of mineral occurrences distributed in the survey area , based on the classification by Sengor et al., 1996, which was published relatively recently and summarized in Chapter 1 Overview. Concerning the types of the ore deposits, the ore types proposed by USGS and Geological Survey of British Columbia were referred.

The geology in Mongolia is characterized by a series of orogenic movements (Sengor et al., 1996) including (1) the formation of accretionary prism in the peripheral area of the continent and the activity of the island arc magmatism, (2) collision of the Siberian Craton and Sino-Korean massif and (3) formation of stable massif, and so the formations of various types of ore deposits occurred during this process of geologic development are expected. The geological features and distribution of the Terrane (Unit) known in the survey area, and the types of ore deposits and the kinds of ores expected existence are given below

.

(1) Darkhat Unit and Sangilen Unit

[Distribution in the survey area]

Darkhat Unit and Sangilen Unit distributes in the northern part of Vitim Suture and the west side of

Khuvsugl Lake where is located in the northern part of the survey area.

[Outline of the geology]

The geology consists of a continental crust of Pre-Baikald and the Riphean magma arc-accretionary prism complex. Further, the geology also comprises the gneiss, schist belonging to the Lower Precambrian, which forms a basement, basalt, rhyolite, tuff and terrigenous sediment, which were produced from the magma arc of the Riphean. There are distributions of the shallow marine limestone, dolomite, phosphate rock, bauxite and the calcic flysch belonging to the Medium to the Cambrian, which irregularly cover previously mentioned geologic constituents. There distribute the metamorphic rock of the green schist facies and the ophiolite in the eastern part of the Unit, which is considered to be accretionary prism complex accompanying the subduction. In the southern part of the Unit, there observed the activity of the

granitic rocks belonging to the Lower Palaeozoic.

[Expected ore deposit]

The list of the known mineral occurrences/points includes the mineral occurrences of gold, copper, tungsten, molybdenum, nickel, chromium, etc., and this indicates that there are possibilities of the existences of nickel, chromium and platinum group ore deposits relating to the ultrabasic rock in the ophiolite and the pegmatite ore deposit relating to the granitic rocks which were active during the Lower Palaeozoic.

(2) Dzhida Unit

[Distribution in the survey area]

Dzhida Unit distributes in the eastern side of the Khuvsugal Lake in the northern part of the survey area.

[Outline of the geology]

The Dzhida Unit consists of the magma arc and accretionary prism belonging to the Lower Palaeozoic. There are distributions of the island arc basalt and the Boninite covering the ophiolite, which is the magma arc belonging to the Pendian to the Lower Cambrian. These geologic constituents are further covered with basalt, andesite, rhyolite, tuff, sandstone and cacic rock. Accretionary prism includes ophiolite, turbidite, chert and a tectonic block consisting of turbidite and reef limestone.

There are distributions of granitic rocks, which were active during the Lower to Upper Palaeozoic in this southern part of the Unit.

[Mineral occurrences/points]

Since the presence of the magma arc formed during the period ranging from the Upper Proterozoic to the Palaeozoic was observed, the existences of nickel, chromium and platinum group ore deposits can be expected. Further, the Tavt ore depositis situated in this Unit, and there is the possibility that the vein type gold and copper deposits occur within the distribution area of granitic rocks, which were active during the Middle to the Upper Palaeozoic.

(3) Tuva-Mongol Unit

[Distribution in the survey area]

Tuva-Mongol Unit distributes widely in the southern part of Vitim Suture and the central-southern parts of the survey area.

[Outline of the geology]

Tuva-Mongol Unit comprises the continental crust prior to the formation of Altaids and magma arc belonging to the Vendian to the Permian. The continental crust forming basement of the island arc comprises migmatite similar to Angara craton, grranitie, anorthosite, granulite, etc.

Further, there is the distribution of the high grade metamorphic rock belonging to the Archean, which was divided by ophiolite during the Vendian to the Lower Cambrian. The magma arc comprises ophiolite of the Vendian to the Lower Cambrian and the island arc volcanic rock of the Riphean.

In the central to western parts of the survey area, there are wide distributions of crushed rocks and volcanic rocks of the Lower to the Middle Palaeozoic, and alkali-calc alkalic granitic rocks of the Lower to the Middle Palaeozoic. In the eastern to central parts of the survey area, the distribution of sediment rocks and volcanic rocks of the Middle to the Upper Palaeozoic is predominant, although there is also the distribution of calc-alkali granitic rocks of the Upper Palaeozoic.

Concerning the origin of this Unit, there is an interpretation that the collision of the micro continents formed the micro continent of the Tuva-Mongol, while accretionary prism and the magma arc developed with the development of the subduction along the periphery of the Tuva-Mongol micro continent (Tumurtogoo, 1996).

[Mineral occurrences/points]

In the central to western parts of the survey area, the existences of the porphyry type, vein type and skarn type copper-molybdenum, lead-zinc and gold deposits relating to granitic rocks which were active during the Lower to the Middle Palaeozoic are expected.

In the central to eastern parts of the survey area, because of Erdenet deposit being located therein, the existence of the porphyry type copper-molybdenum deposit relating to granitic rocks which were active during the Permian to the Triassic can be expected. Further, the existences of the high sulfidation and low sulfidation type epithermal gold deposit, polymetallic vein type deposit and skarn type deposit can also be expected.

(4) Khangay-Khentiey Unit

[Distribution in the survey area]

Khangay-Khentiey Unit distributes in the southeastern end to southern end in the survey area .

[Outline of the geology]

Khangay-Khentiey Unit consists of accretionary prism and the magma arc. The unit comprises ophiolite, serpentinite mélange, chert, limestone and shale of the Upper Riphean(?) to the Lower Cambrian; turbidite, basic-neutral volcanic rock, tuff and chert of the Lower Palaeozic to the Carboniferous; turbidite, gabbro and basalt of the Carboniferous to the Triassic. There observed the existence of fragments of some island arcs, the fragments having polarity becoming younger towards the northeastern direction.

This Unit shows the evidences of its activity of the granitic rocks during the Permian, the Triassic and the Jurassic.

[Mineral occurrences/points]

As the Zaamar gold deposit is situated in this Unit, the existence of the vein type gold deposit relating to plutonic rock accompanying the activity of granitic rocks is expected, and the existence of porphyric type ore deposit and skarn type ore deposit can also be expected.

5.2 Potentiality of existence of ore deposits and selection of promising districts, and mineral occurrences/points

5.2.1 Potentiality of existence of ore deposits

The Geological evolution of Mongolian is characterized by the formation of magmatic arc and accretionary prism since the Vendian, and collision of the Angaraa Craton and Northern China Craton afterwards (e.g., Sengor et al., 1996). Regionally, the survey area is consisted with remnants of various kinds phenomena happened at plate convergence area. It is expected that various types of ore deposit formed in the plate convergence area such as porphyry type copper, gold, and molybdenum deposits, skarn type copper, lead, and zinc deposits, epithermal type gold ore deposits, pluton-related gold deposits, and *kuroko* discovered under the tectonic environment of magmatic arc. Also, Cyprus type copper deposits and chromium/platinum group deposits may be expected in ophiolite under the such tectonic environment as an accretionary prism (Mitchell and Garson, 1981). Main deposit types in the survey area are porphyry type copper/molybdenum deposits, skarn type copper/lead/zinc deposits, epithermal type gold deposits, skarn type copper gold deposits, and pluton-related gold deposits. The potential of each ore deposit type is described below.

①Porphyry type copper/molybdenum deposit

A typical deposit of the survey area is the Erdenet deposit. The mineral occurrences related to this type of mineralization are the Tsagaan chuluut, Mogoin gol 2, Zuukhiin gol, Danbatseren, Tourmaline, Shand, Oyut, and Undrakh mineral occurrences in the Erdenet West district and the Naranbulag mineral occurrence in the Tososntsengel district. The Erdenet West district belongs to the Tuva – Mongol unit consisting of volcanic arc igneous rocks. Volcanic rock and granite classified as calc-alkaline rock of the Permian to Triassic are distributed over the Erdnet West district, which satisfies the tectonic environment which forms porphyry copper/molybdenum deposits.

The formation of the Erdenet deposit is considered to have accompanied the Erdenet porphyritic intrusion complex that intruded into the Selenge complex.

The radioactivity ages of the Erdenet Porphyritic Intrusion Complex and the Erdenet deposit range between 196±4 and 253±28 Ma and 202±4 and 240±0.8, respectively (Figure II-5-1).

In particular, magmatic activity in this period is thought to be important for formation of minaralization.

The Erdenet deposit consists of the Erdenet NW deposit in operation, the untapped Erdenet Central deposit, the Oyut (Erdenet SE) mineralized zone, the Intermediate mineralized zone, and the Tsagaan chuluut mineral occurrence, which are distributed in the NW-SE direction. Macroscopically, the Selenge complex including the Mogoin gol 2, Khujiriin gol, Tourmaline, Danbatseren, and Shand mineral occurrences are also distributed in the NW-SE direction like the Erdenet deposit.

In porphyry systems, it is generally thought that a hydrothermal system that formed porphyry type deposits forms advanced argillic alteration (lithocap) at shallow depth. High sulfidation type gold deposits are formed inside it and porphyry deposits are formed at deep depth (Figure II-5-2). Consequently, if there is little denudation of the magmatic hydrothermal system, advanced argillic alteration remains at present surface. If the denudation advances, the porphyry deposits itself eventually crops out. Since the denudation of magmatic hydrothermal system has advanced in the Erdenet deposit, the deposit cropped out.

The Erdenet deposit is considered to be inclined toward the northwest. A "secondary quartzite" corresponding to advanced argillic zone develops in the Tsagaan chuluut and Mogoin gol 2 mineral occurrences in the northwestern part of the Erdenet deposit. Figure II-5-3 shows a conceptual superimposition of porphyry systems over a geologic profile in the NW-SE direction that connects the Erdenet deposit and the Mogoin gol 2 mineral occurrence. Andalusite was identified at some points of the advanced argillic alteration zone in the Mogoin gol 2 mineral occurrence. Compared to the Tsagaan chuluut mineral occurrence, it is assumed that a relatively deep area crops out. Consequently, porphyry type copper/molybdenum deposits and/or high sulfidation type gold deposit are expected to exist below andalusite. The Danabatseren mineral occurrence is situated in the west of the Erdenet deposit. Similarly, the upper part of the advanced argillic alteration zone appears at present surface in the Tsagaan chuluut mineral occurrence and porphyry type copper/molybdenum deposits and/or high sulfidation type gold deposit are expected to exist below the alteration zone.

On the other hand, in the Zuukhiin gol mineral occurrences oxide copper crops out in potassic alteration zone. An ore body for SX-EW is expected to exist at shallow depth. In the Khujiriin gol mineral occurrence, the outcrop of potassic alteration zone is caused by the hydrothermal alteration of another stage because the homozenization temperature of fluid inclusions of quartz veins accompanied with copper oxide were as low as 142 – 239 ℃. For this reason, it was concluded that the Khujiriin gol mineral occurrence is barren of porphyry type copper/molybdenum deposits.

The Tososntsengel district belongs to the Tuva-Mongol unit. Plutonic rock of the Precambrian to the Permian and volcanic rock of the Permian to the Triassic are distributed near

the Naranbulag mineral occurrence in this district. Since granite is chemically composed of volcanic arc calc-alkaline, the Tososntsengel district is in a tectonic setting similar to that of the Erdenet West district. Since the granite underwent potassic alteration and copper oxide ore can be seen, it may indicate a relatively deep level of the porphyry system. Like the Zuukhiin gol mineral occurrence, the development into copper oxide deposit in the lower part is expected.

②Skarn type copper/lead/zinc deposit and skarn type gold deposit

The Ulzit ovoo mineral occurrence in the Zaamar district, the Holboo ovoo mineral occurrence in the Uubulan district, the Skarn mineral occurrence in the Altgana gol NW district, the Hurilt gol mineral occurrence in the khokhoo district, 20 a point, and 20 d point are classified as a skarn type copper/lead/zinc deposit in the survey area. Meanwhile, the Teshig mineral occurrence in the Tavt district is classified as a skarn type gold deposit.

The skarn of the Ulzit ovoo mineral occurrence was determined by boring which followed the magnetic exploration and IP method electric exploration. Its extension is not known. A Mongolian private company is now exploring the Teshig prospect and estimates the amount of geologic resources of gold at 4 t. A value of Au: 0.125 – 0.0051 g/t was obtained from the chemical analysis of skarn of the Teshig mineral occurrence in the this survey. Generally speaking, the skarn type mineral occurrences other than the Teshig mineral occurrence are thought to be small scale and some of them could not be discovered even through the field survey. It is concluded that there is little possibility that a deposit having an economic value exists. However, if carbonate rock is distributed near a porphyry system, a skarn deposit is most likely to be formed. In future, it is advisable to pay attention to this point all over the survey area where the plutonic magmatism was active.

③Epithermal gold/silver ore deposit

The Oyuut Khonkhor mineral occurrence in the Bulgan SW district and Tsookher mert mineral occurrence in the Erdenet West district are classified as an epithermal type gold/silver deposit in the survey area. Both of them belong to the Tuva – Mongol unit.

In the Oyuut khonkhor mineral occurrence, 8.8 g/t Au was recorded in brecciated rhyolite through the Mongolian scientific research. Though the gold grade was low, quartz veins (float) and gossans were found in this survey. The extension of silicification/argillization (Sericite > kaolinite) was discovered. Hydrothermal breccia is present. These findings indicate that there was neutral pH > acid hydrothermal activity at least at the present surface level.

On the other hand, in the Tsookher mert mineral occurrence of the Erdenet West district, an analysis value of 285.4 g/t Au was obtained from a quartz veinlet zone (analysis width: 30 cm) in granite through the this survey. In addition, 0.395 – 6.29 g/t Au was obtained from a chip sample. The existence of high grade auriferous quartz vein is expected in granite near this

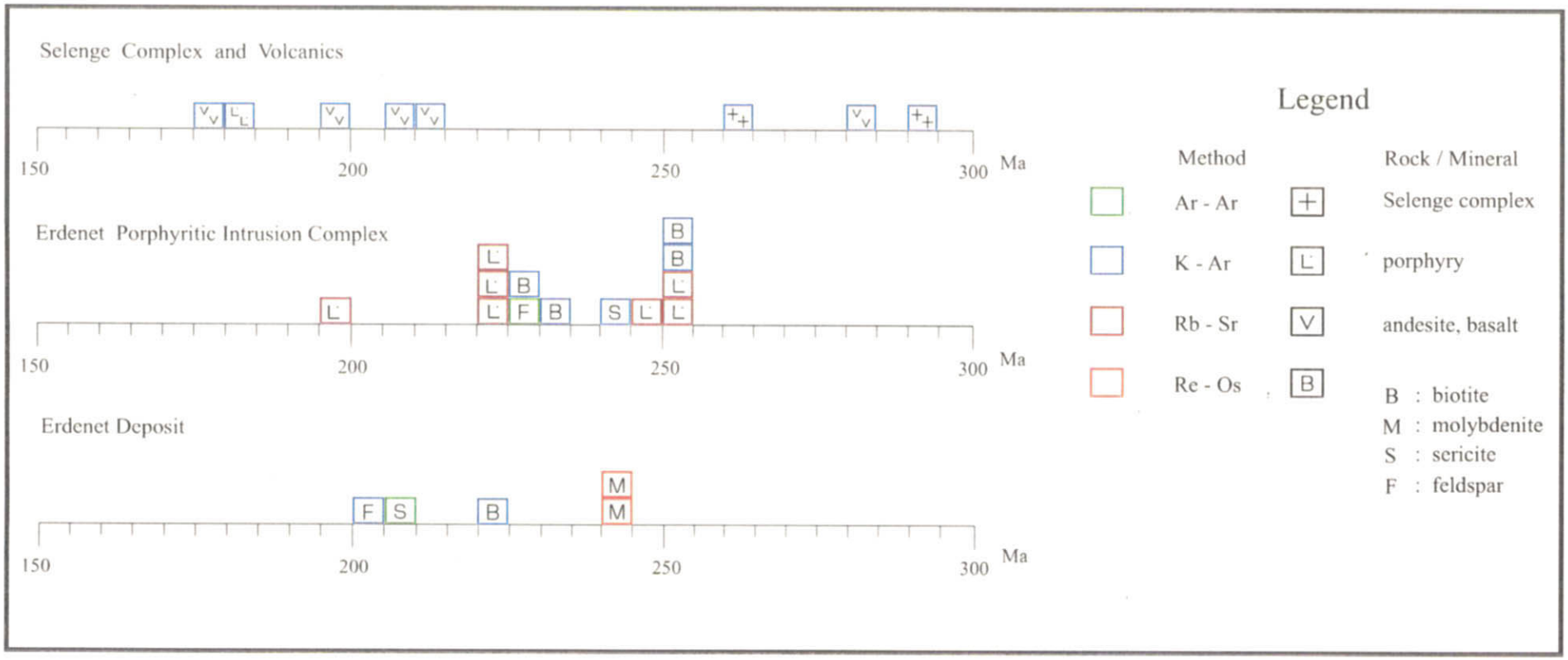

Fig. II-5-1 Radiometric age of Selenge complex, Erdenet porphyritic intrusion complex and Erdenet deposit (taken from Sotnikovetal., 1995; Berzina et al., 1999; Watanabe and Stein, 2000; JICA-MMAJ, 2000)

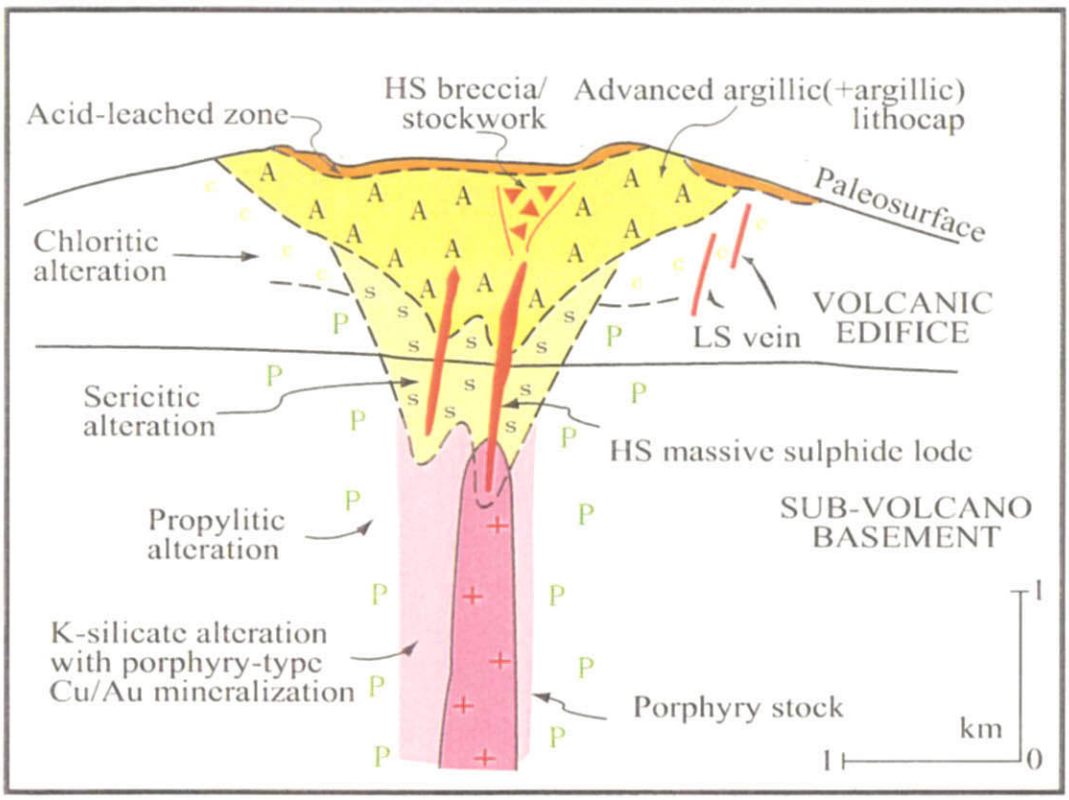

Fig. II-5-2 Idealized advanced argillic alteration (lithocap) and underlying porphyry Cu/Au deposit taken from Sillitoe 1995

Erdenet West

Erdenet

Bulgan

Bulgan West

Bulgan SW

Bulgan NW

Khujiriin gol

Mogoin gol 2

Tsagaan Chuluut

Erdenet NW

Erdenet Central

Oyut (Erdenet SE)

Tourmaline

Zaluu

Mt. Zayn davaa

Danbaiseren

Jasiin buuts

Tsookher nert

Khar uul

Burged khyr

Ereen ikher

Nomgon

Zaiian

Urmiin tsgaan muu

Aguil

Undrakh

Khuskhuut gol

Oyuut khonkhor

SAR127

SAR25

SAR136

SAR144

SAR138

SAR139

SAR181

SAR182

SAR183

SAR194

SAR197

SAR202

SAR205

SAR204

SAR219

SAR222

SAR221

SAR188

SAR200

SAR235

SAR238

SAR239

SAR233

A

B

A ←NW

B SE→

Erdenet deposits

Mogoin gol

Tsagaan chuluut

NW Central

Intermediate

Oyut

LEGEND

Triassic (T2-T3) Volcanics

Triassic Erdenet complex

Strong silicification

Fault

Permian–Triassic Selenge complex

Advanced argillic & sericite alteration

Geological cross section along the Oyut - Erdenet NW -Tsaggan chullut - Mogoin gol 2 deposits and mineral occurrences in the Erdenet West district

0 10 20 30km

LEGEND

"secondary quartzite"

Selenge complex

Survey district

1st Phase

2nd Phase

Investigated area

Under

Preceding survey

Under

This survey

Fig. II-5-3 Distribution of "secondary quartzite" and Selenge complex, and geological cross section along the Oyut - Erdenet NW - Tsaggan chullut - Mogoin gol 2 deposits and mineral occurrences in the Erdenet West district

mineral occurrence. In particular, as described above, signs of hydrothermal activity related to the porphyry system remain in the southeastern part of the survey area including the Erdenet West district. It is most likely that this type of gold deposit will exist around that place.

④Plutonic rock related gold ore deposit

The Ereen mineral occurrence of the Tavt district which belongs to the Tuva – Mongol unit is classified as pluton- related gold deposit in the survey area. Numerous gold mineral occurrences are known in the Zaamar massif including Sudal N117 prospect of the Zaamar district. The area along the Tuul River is considered to be an alluvial gold deposit source. In the present survey, Sudal N117 mineral occurrence was considered to be an epithermal ore deposit. However, it is likely to be pluton- related gold deposit because there are few signs of volcanic activity around that area.

The Ereen mineral occurrence has auriferous quarts veins that develop in the shear zones in granite. Within the range of 5 km x 5 km, ten ore bodies of the NE-SE trending system (approximately 100 quartz veins containing gold) are known. In this survey, a value of 54.14 g/t Au has been obtained from a quartz vein chip sample. An existing document describes that the grade ranges between 0.1 g/t Au and 250 g/t Au. According to the Mining Journal (1997), the estimated amount of gold is 100 to 130 tons. A Mongolian private company is now exploring gold. It is reported that the amount of gold in these ore bodies including No. 3 ore body, the major vein, is estimated at 8 tons. The whole area around the Ereen mineral occurrence has a high potential of existence of gold ore deposits, but sufficient survey has not been conducted yet.

⑤Platinum group deposits associated ophiolite

Ultramafic rock that accompanies with ophiolite is distributed in the eastern part of the Khuvsgul Lake (for example, the Altagana gol district and the south camp district selected in this survey) corresponding to the Dzhida unit. Around that place, a small-scale platinum group alluvial deposit originated from the ultramafic rock may exist. Though distant and small in scale, a platinum group deposit of high value can be considered as an important ore deposit type in Mongolia poor in infrastructure because there will be an increasing demand in catalyst in the future.

5.2.2 Selection of promising districts and mineral occurrences/points

With respect to the mineral occurrences/points where ground truth was conducted, ten mineral occurrences were selected as promising ones judging from the tectonic setting,

size/dimension and characteristics of alteration and mineralization zone, and multivariate analysis of geochemical data, where further surveys are desirable (Table II-5-1, Figure II-5-4). For evaluation of the selected 103 mineral occurrences/points, refer to Appendix. The mineral occurrences/points selected for further exploration and reasons for their selection are shown as follows.

① Tsagaan chuluut mineral occurrence in Erdenet West district

This is a mineral occurrence adjacent to the Erdenet NW Deposit. Secondary quartzite showing advanced argillic alteration is widely distributed in its vicinity. As a result of geochemical analysis, this mineral occurrence was found to show characteristics of advanced argillic alteration. Although the score of the seventh principal component related to Cu/Mo mineralization is low, the score of the second principal component is high in its correlation with Al and P, which is a characteristic of advanced argillic alteration. Moreover, also taking into consideration the result of powdery X-ray diffraction of silicificated rocks, those with high scores of the second principal component correspond to the samples which contain alunite and kaolinite, and this suggests advanced argillic alteration. Further, andalusite was detected, showing a characteristic of relatively deep level of advanced argillic alteration. From these, although no mineral showings is observed on the surface, existence porphyry type copper/molybdenum deposits at deep depth and high sulfidation type gold deposit at shallow depth is expected, whose types are similar to those in the Erenet Deposit. Although detailed status is unknown, mineralization of copper (Cu: 0.75%) was captured near the depth of 275 m through boring survey conducted in thismineral occurrence, and this fact supports the above expectation.

② Mogoin gol 2 mineral occurrence in the Erdenet West district

This mineral occurrence is located approximately 30 km to the northwest of the Erdenet Deposit. Like Tsagaan chuluut mineral occurrence, "secondary quartzite" is distributed here; with geochemical data indicating the characteristics of advanced argillic alteration, and silicified rocks accompanying andaulsite has been identified. Consequently, existence of porphyry type copper/molybdenum deposits of the same type as that of Erdenet deposit is expected at deep depth. Further, since copper oxide exists on the surface, the depth where the deposit may exist is presumed as shallower level than that of Tsagaan chuluut mineral occurrence.

③ Zuukhin gol prospect in Erdenet West district

This is a mineral occurrence located approximately 20 km to the north-northeast of Erdenet Deposit. Copper oxide cropped out in potassic alteration zone, and existence of ore body for SX-EW is expected.

④Danbatseren mineral occurrence in Erdenet West district

This mineral occurrence is located approximately 40 km to the southwest of Erdenet Deposit. "secondary quartzite" accompanying andalusite is distributed here, and existence of porphyry type copper/molybdenum odeposit at deep depth and/or high sulfidation type gold deposit at shallow depth is expected.

⑤ Undrakh prospect in Erdenet West district

This mineral occurrence is located approximately 100 km to the west-southwest of Erdenet Deposit. Potassic alteration zone accompanying copper oxide developed, and existence of copper oxide deposit at shallow depth is expected.

⑥ Tsookher mert mineral occurrence in Erdenet West district

This mineral occurrence is located approximately 70 km to the west-southwest of Erdenet Deposit. 285.4 g/t Au was obtained from a quartz veinlet zone in granite (analysis width: 30 cm), and existence of high-grade auriferous quartz vein deposit at shallow depth is expected.

⑦ Oyuut khonkhor mineral occurrence in Bulgan SW district

This mineral occurrence is located approximately 120 km to the southwest of Erdenet Deposit. As a result of this survey, analysis value 0.45 g/t Au was obtained from quartz vein (floats). As a result of an academic examination in Mongolia, 8.8 g/t Au was obtained from brecciated rhyolite. Also, 4.4 g/t Au was obtained from a boring survey. In view of the fact that the mineral occurrence incurred neutral pH >acidic argillization, existence in its periphery of auriferous quartz vein deposit is expected. A Mongolian private company obtained a mining right last year and commenced it exploration.

⑧ Ereen prospect in Tavt district

This mineral occurrence is located approximately 150 km to the northwest of Erdenet city. A Mongolian private company started its exploration in 1995, and 10 ore bodies (about 100 auriferous quartz veins) were captured so far within a range of 5 km x 5 km. There is a high possibility where a deposit of similar type exists in the vicinity of Ereen prospect.

⑨ Teshig prospect in Tavt district

This mineral occurrence is located approximately 120 km to the northwest of Erdenet city. A Mongolian private company is now conducting an exploration, and 4 t is presumed as the amount of geological resource of gold. There is a high possibility where a deposit of similar type exists in the vicinity of Teshing mineral occurrence.

⑩ Naranbulag mineral occurrence in Tosontsenegl district

This prospect is approximately 40 km to the southeast of Tosontsengel town. Potassic alteration zone accompanying copper oxide developed, and existence of oxide copper ore at shallow depth expected. However, taking into account the infrastructure for mining operation, preference of execution of detailed survey in this mineral occurrence is lowered.

The following mineral occurrences/points which were determined as promising in the Phase-I survey were excluded from promising mineral occurrences as a result of review of characteristics and extension of alteration and mineralization, and assay result::

Erdenet district: SAR 138, 139 and 235 points ,Burget Khyr, Mt.Zain gobaav, Under

Bulgan district: SAR 204

Zaamar district: Ulzit

Khokhoo district: 20a and 20d

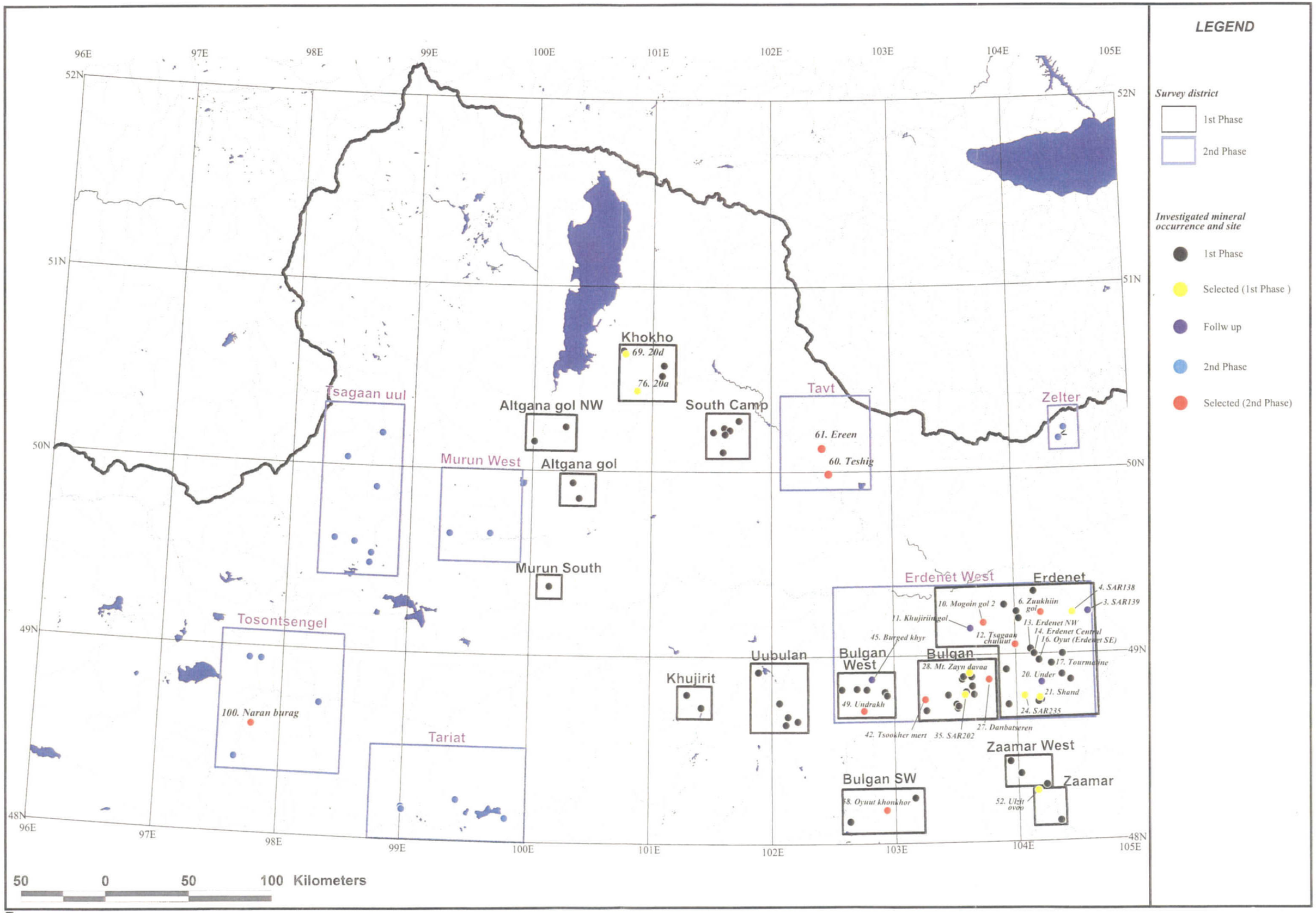

Fig. II-5-4 Selected mineral occurrences and sites in the central north area

Table II-5-1 Selected promising mineral occurrences of the central north area

Region	Mineral occurrence	Expected deposit type	Results of previous survey	Geology	Alteration		Mineralization	PC*2	Remarks
					Characteristics	Alteration mineral assemblages			
Erdenet West	Zuukhiin gol	Porphyry Cu・Mo	Cu:0.11-0.17%, Mo:0.003-0.007% (drill core), 21 drill holes	Selenge complex, micro diorite, dacite-andesite porphyry, dacite and andesite volcanics	Potassic alteration		Oxide copper	C	Oxide copper deposits are expected beneath the surface at shallow
	Mogoin gol	Porphyry Cu・Mo, Epithermal Au	Cu:0.034-0.074%, Mo:0.002-0.018% (ore sample), FE:6%(IP method)	Selenge complex, Permian volcanics, late Triassic-early Jurassic volcanics	"secondary quartzite"(2km*4km) with sericite, alunite, andalusite and kaolinite	Quartz＋Serisite＋Alunite＋Kaolinite, Quartz＋kaolinite±Andalusite	Oxide copper	A	Epithermal Au deposits are expected within "secondary quartzite"and porphyry Cu ・Mo deposits are expected beneath it at deep
	Tsagaan chuluut	Porphyry Cu・Mo, Epithermal Au	Cu:0.75% (drill core length 15m)	Selenge complex, Permian-Triassic volcanics,	"secondary quartzite" (12km*4km) with sericite, alunite, andalusite and kaolinite	Quartz＋Kaolinite＋Alunite, Quartz ＋Sericite＋Kaolinite±Andalusite		A	Epithermal Au deposits are expected within "secondary quartzite"and porphyry Cu ・Mo deposits are expected beneath it at deep
	Danbatseren	Porphyry Cu・Mo, Epithermal Au	High resistivity and FE detected by IP method, weak geochemical anomaly (Cu, Pb, Zn, Mo, Au)	Selenge complex, rhyolite intrusion	"secondary quartzite" (0.5km*0.3km) with sericite, alunite, pyrophylite, andalusite and kaolinite	Quartz＋Serisite＋kaolinite Pyrophyllite±Andalusite		B	Epithermal Au deposits are expected within "secondary quartzite"and porphyry Cu ・Mo deposits are expected beneath it at deep
	Tsookher mert	Epithermal Au	Cu:0.02-0.3%, Au:3-10g/t, Ag:20-500g/t (quartz vein)	Selenge complex, dacite intrusion	Wall rock alteration (silicification, sericite)	Quartz＋Kaolinite, Quartz＋Sericite	Quartz veinlet with oxide copper, spharelite and etc., Au:285.4g/t, Ag:950g/t, Cu:624ppm, Pb:8.99%, Zn:0.101% (width: 30cm)	C	High grade auriferous quartz veins are expected beneath the surface at shallow
	Undrakh	Porphyry Cu	Cu:0.5-0.7% (point samples)	Selenge complex, aplite	Potassic alteration (300m*150m+)		Oxide copper, chalcopyrite,	B	Primary and oxide copper deposits are expected beneath the surface at shallow
Tavt	Ereen*1	Pluton related Au	Au reserve: 8t	Cambrian-Ordovician granitoids, Permian-Triassic granitoids and sedimentary rocks	10 Au deposits in 100km^2	Muscovite＋K-feldspar	around 100 quartz veins in granitoids, strongly controlled by NW-SE fracture, Au:6.3g/t	D	Besides No.1 No.2 and No.3 ore bodies, more gold deposits are expected around the Ereen prospect
	Teshig*1	Skarn Au	Geological Au resource: 4t, Au:10g/t-30g/t in skarn	Vendian-Cambrian sediments, Devonian plutonic rocks		Epidote＋Magnetite skarn	Au:0.05g/t-0.125g/t in epidote and magnetite skarn	D	More gold deposits are expected around the Teshig prospect
Bulgan SW	Oyuut khonkhor*1	Epithermal Au	Au:4.4g/t, Ag:0.2g/t (drill core)	Volcanics of the Mogod formation, granitic dyke	Neutral pH>acid argillic alteration and silicification	Quartz＋Sericite±Kaolinite±Alunite	Au:0.45g/t, Ag:10.2g/t (float of quartz vein)	C	Epithermal Au deposits are expected beneath the surface at shallow
Tosontsengel	Naranbulag	Porphyry Cu・Mo	Estimated reserve: 22,000,000t, Cu:0.28%, Mo:0.001-0.015%	Lower Permian volcano-plutonic rocks	Potassic alteration	Quartz＋Sericite±Kaolinite	Oxide copper	D?	Primary and oxide copper deposit are thought to be expected beneath the surface

*1 Under exploration by the Mongolian private company

*2 Principal Component, see Table II-4-1, II-4-2 and II-4-3 in details