1 - 4 Discussions

1-4-1 Principal component analysis

The Principal Components Analysis (PCA) was executed based on a correlation coefficient matrix calculated from logarithmic analysis results of stream sediments samples. The results of PCA are shown in Table II-1-4. Eigenvalues up to the third principal component (Z-1 to Z-3) are above 2.8. Cumulative contribution up to the third principal component is 42.9%. The PCA score contour maps from Z-1 up to Z-3 are shown in Fig.II-1-4-(1)～(3).

[First principal component] (Z- 1) (Fig.II-1-4-(1))

The first principal component (Z-1) contributes approximately 19.4% of original variability. The factor loadings of Fe, Co, V, Zn and Mn are highly positive. These elements seem to compose opaque or colored minerals. The factor loadings of Na, K and Al are negative. These elements seem to compose colourless silicate minerals. The ranges of positive scores are distributed from the Waidina River to the south coast, the upper stream of Rewa River, the north of Vunaniu Bay and the upper Sigatoka River.

[Second principal component] (Z- 2) (Fig.II-1-4-(2))

The second principal component (Z-2) contributes approximately 13.7% of original variability. The factor loadings of Mg, Ca, Sr, P and Ni are positive. No element has especially strong negative factor loading. The ranges of positive scores are around the Namosi area, around the Sovi Basin and along the middle-upper stream of Sigatoka River. Meanwhile the ranges of negative scores are distributed in the Sovi Basin, in the middle-south coast and the southwest coast. According to the geological map of this area, the ranges of positive scores roughly correspond to sedimentary rocks, volcaniclastic rocks and volcanic rock, and the ranges of negative scores roughly correspond to intrusive rocks.

[Third principal component] (Z- 3) (Fig.II-1-4-(3))

The third principal component contributes approximately 9.7% of original variability. The factor loadings of As, Hg, Cu, Au and S are positive. These elements have a relation with Cu-Au mineralization. The factor loadings of Ca and Na are negative. From a viewpoint of these positive scored ranges, high positive score ranges are distributed in the Namosi area that is hosting porphyry Cu-Au deposits, the upper Waimanu River area that is hosting Au mineralization and the Wainaleka area that is hosting massive sulfide Cu deposits. Other positive scored ranges are also concordant with known Cu or Au mineral occurrences.

1-4-2 Geochemical characteristic of each river drainage system

TableII-1-5, shows the basic statistic values of chemical analysis of stream sediments from each drainage system. The geochemical characteristic of each drainage system is described as follows.

(1) The Rewa River drainage system

The Rewa River drainage system consists of the main Rewa River, the Wainimala River, the Sovi River, the Waidina River and the Waimanu River. According to Table II-1-5, logarithmic averages of Au, As, Ba, Be, Cr, Cu, Fe, Mn, Pb, S and Zn of the Rewa drainage system are higher than those of other drainage systems. These elements are characteristic of hydrothermal deposits. Some porphyry Cu-Au deposits represented by Namosi area and Wainadoi Au mineral occurrences in the upper Waimanu River explain this characteristic. While, logarithmic averages of Al, Na and Sb of the Rewa drainage system are lower than those of other drainage systems.

(2) The Navua River drainage system

The Navua River drainage system consists of the main Navua River, the Wainikoroiluva River, the Wainikovu River, the Veinuga River and the Wainamoli River. According to Table II-1-5, logarithmic averages of Al and Mo of the Navua drainage system are somewhat higher than those of other drainage systems. As for other elements, logarithmic averages of As, Cr, Cu, Cd, Sb, S, Ni, Na, Mg and P of the Navua drainage system are the second highest values compared with other drainage systems. The Navua River drainage system is partly influenced by hydrothermal deposits.

(3) The Sigatoka River drainage basin

For the Sigatoka River drainage system, it consists of the main Sigatoka River, the Namada River, the Busa Creek, the Yalavou Creek, the Nasikawa Creek and the Nasa Creek. According to TableII-1-5, logarithmic averages of Ca, Mg, Cd, Co, Na, Ni, P, Sb, Sr, V and W of Sigatoka drainage system are higher than those of other drainage systems. The Ca and Mg averages are specifically high. This is influenced by limestone around the Sigatoka River drainage system.

(4) The Coastal Rivers

Differ from above 3 drainage systems, the Coastal Rivers are small sized rivers that flow from north to south in a range of approximately 10 km width from the south coastline of Viti Levu Island. These rivers are not connected each other as a same drainage system. According to Table II-1-5, logarithmic average of the elements except Au, Bi, Mn, Sb, W and Zn among 29 elements, are lower than those of other drainage systems.

1-4-3 Summary

The stream sediment survey was executed in order to confirm the geochemical characteristics of stream sediments in the survey area. A total of 1845 stream sediment samples (within which 128 samples are duplicates) were collected from 1717 points in rivers or creeks within the survey area. For laboratory and sample preparation, these samples were sieved under 80 mesh (180μm) in the field. The samples were analysed for 29 chemical elements by ICP-AES or AAS in laboratory. The analysis results were compiled and examined for comprehensible regional geochemical characteristics of the survey area. Furthermore, these data were multivariate - statistically handled for principal component analysis.

The drainage system of the survey area is composed of the Rewa river, the Navua river and the Sigatoka river and exceptive the Coastal Rivers. The geochemical characteristic of stream sediment in the survey area is summarized as follows.

The Ca, Mg and Na indicate high values in the northwest part of the area within the main rock forming elements such as Al, Ca, K, Na, Mg and P. Among them, Ca and Mg show specifically high values in the middle stream of the Sigatoka River, which is due to surrounding carbonate rocks such as limestone. While Ba, Cr and V reflect the background geology. The Cr shows specifically high value in distribution range of the Verata group on the eastern part of the area. In general, Ag, As, Au, Cd, Cu, Hg, Mo, Pb, S, Sb and Zn are associated with hydrothermal mineralization. Among them, high ranges of Ag, As and Hg are scattered in the area. The Au anomalies are concentrated on a large-scale mineralized zone in Namosi area, some Au mineral occurrences of the upper Waimanu River and Wainadoi River, and also small sized Au anomalies are scattered in throughout the area. The Cu values are specifically high around the large-scale mineralized zone in Namosi area, which is currently undergoing with exploration activities. The anomalies of Mo, Pb and Zn are surrounding the Cu anomalies. A small anomaly of Mo was detected at the eastern side of Wainaleka mineral occurrence that is known as a porphyry type deposit (Echo Creek).

In the principal component analysis, the first to the third principal components were examined. In the first principal component, elements forming coloured minerals or opaque minerals contribute to positive score and elements forming colourless minerals contribute to negative score. In the second principal component, sedimentary rocks, volcaniclastic rocks and volcanic rocks have a weak relation to positive scored area while intrusive rocks have a weak relation to negative scored area. In the third principal component, hydrothermal Cu-Au deposits affect positive score and high scored range are in harmony with the location of Cu-Au mineral occurrences.

Table II-1-4 Result of principal component analysis of the stream sediment samples

Result of PCA

No.	Eig_value	Eig_pct	Eig_sum
Z-1	5.628	19.405	19.405
Z-2	3.981	13.729	33.135
Z-3	2.820	9.724	42.859
Z-4	2.179	7.514	50.373
Z-5	1.737	5.991	56.364
Z-6	1.274	4.394	60.758
Z-7	1.137	3.920	64.678
Z-8	1.074	3.704	68.381
Z-9	1.003	3.457	71.838
Z-10	0.921	3.174	75.013
Z-11	0.860	2.966	77.979
Z-12	0.827	2.851	80.830
Z-13	0.775	2.673	83.503
Z-14	0.621	2.142	85.645
Z-15	0.587	2.026	87.671
Z-16	0.540	1.862	89.533
Z-17	0.481	1.659	91.192
Z-18	0.416	1.434	92.626
Z-19	0.336	1.159	93.785
Z-20	0.314	1.083	94.868
Z-21	0.269	0.926	95.795
Z-22	0.230	0.792	96.587
Z-23	0.208	0.719	97.305
Z-24	0.196	0.676	97.982
Z-25	0.188	0.647	98.629
Z-26	0.146	0.505	99.134
Z-27	0.110	0.381	99.515
Z-28	0.081	0.279	99.794
Z-29	0.060	0.206	100.000

Factor loading

Fact_Id	Z-1	Z-2	Z-3	Z-4	Z-5	Z-6	Z-7	Z-8	Z-9	Z-10
Fe	0.874	0.063	-0.004	-0.034	0.285	0.221	0.059	0.000	0.015	-0.005
Co	0.761	0.500	0.019	-0.212	-0.128	0.015	-0.044	-0.025	-0.084	-0.074
V	0.749	0.375	0.024	-0.027	0.242	0.171	0.213	0.010	-0.022	0.056
Zn	0.744	0.088	0.317	-0.039	0.091	0.097	-0.135	-0.069	-0.089	-0.268
Mn	0.706	-0.192	-0.160	-0.001	0.299	0.215	-0.060	-0.074	0.114	-0.120
Ba	-0.498	0.377	0.336	0.023	0.258	0.294	-0.348	0.044	0.208	-0.049
Al	-0.555	0.497	0.182	-0.082	-0.266	-0.013	0.004	-0.164	-0.198	-0.122
K	-0.589	0.319	0.212	0.073	0.243	0.261	-0.264	0.143	0.290	-0.056
Na	-0.606	0.304	-0.463	0.037	0.237	-0.129	0.005	0.073	0.012	-0.051
Mg	0.177	0.842	-0.185	-0.180	-0.026	-0.125	0.004	-0.016	-0.124	-0.147
Ca	-0.104	0.636	-0.570	-0.121	0.244	-0.145	0.067	0.047	-0.138	-0.055
Sr	-0.411	0.598	-0.165	-0.266	0.199	0.186	-0.017	0.020	-0.152	0.034
P	-0.516	0.592	0.195	0.284	0.018	0.004	0.144	-0.078	-0.031	-0.008
Ni	0.322	0.589	-0.040	-0.349	-0.384	-0.261	-0.076	0.017	0.174	0.130
As	-0.083	0.099	0.629	0.066	0.110	-0.231	-0.072	0.134	-0.163	0.164
Hg	-0.029	-0.070	0.605	-0.088	-0.378	0.088	0.023	-0.246	-0.010	0.033
Cu	0.366	0.505	0.597	-0.107	-0.226	0.042	-0.054	-0.061	-0.081	-0.073
W	0.399	0.175	-0.186	0.710	-0.294	-0.053	-0.124	0.057	0.067	-0.002
Cd	0.427	0.248	-0.171	0.663	-0.139	-0.161	-0.071	0.074	-0.046	-0.014
Be	-0.083	0.274	-0.117	0.584	-0.360	0.301	-0.112	0.264	0.103	0.037
Mo	0.047	-0.043	0.287	0.136	0.490	-0.391	0.089	-0.151	0.109	0.239
S	-0.297	0.241	0.419	0.186	0.088	-0.078	0.469	-0.021	0.046	0.028
Ti	0.200	0.417	0.015	0.291	0.220	0.352	0.424	-0.183	0.201	0.186
Ag	0.146	-0.053	0.139	-0.010	0.091	-0.203	0.257	0.681	-0.099	-0.272
Cr	0.253	0.246	-0.235	-0.410	-0.248	-0.120	-0.006	0.158	0.501	0.423
Bi	0.219	0.079	0.057	0.050	0.242	0.099	-0.411	0.159	-0.479	0.530
Au	0.069	0.032	0.446	0.013	-0.017	-0.005	0.203	0.382	-0.005	0.188
Sb	0.143	0.186	-0.019	0.420	0.186	-0.462	-0.145	-0.331	0.034	0.017
Pb	0.206	0.124	0.361	-0.048	0.287	-0.292	-0.310	0.107	0.350	-0.252

Eigen vector

Eig_vec	Z-1	Z-2	Z-3	Z-4	Z-5	Z-6	Z-7	Z-8	Z-9	Z-10
Fe	0.368	0.032	-0.003	-0.023	0.216	0.196	0.055	0.000	0.015	-0.005
Co	0.321	0.251	0.011	-0.144	-0.097	0.014	-0.041	-0.024	-0.084	-0.077
V	0.316	0.188	0.014	-0.019	0.183	0.151	0.199	0.010	-0.022	0.058
Zn	0.314	0.044	0.189	-0.026	0.069	0.086	-0.126	-0.067	-0.089	-0.279
Mn	0.298	-0.096	-0.095	-0.001	0.227	0.190	-0.057	-0.072	0.113	-0.125
Ba	-0.210	0.189	0.200	0.015	0.196	0.261	-0.327	0.043	0.207	-0.051
Al	-0.234	0.249	0.108	-0.056	-0.202	-0.012	0.004	-0.158	-0.198	-0.127
K	-0.248	0.160	0.126	0.049	0.185	0.231	-0.247	0.138	0.289	-0.058
Na	-0.255	0.153	-0.276	0.025	0.180	-0.114	0.005	0.070	0.012	-0.053
Mg	0.075	0.422	-0.110	-0.122	-0.020	-0.111	0.004	-0.015	-0.123	-0.153
Ca	-0.044	0.319	-0.340	-0.082	0.185	-0.129	0.063	0.046	-0.138	-0.057
Sr	-0.173	0.300	-0.098	-0.180	0.151	0.165	-0.016	0.019	-0.152	0.035
P	-0.218	0.296	0.116	0.192	0.014	0.003	0.135	-0.076	-0.031	-0.008
Ni	0.136	0.295	-0.024	-0.236	-0.291	-0.231	-0.071	0.016	0.174	0.136
As	-0.035	0.050	0.375	0.045	0.084	-0.205	-0.068	0.129	-0.162	0.170
Hg	-0.012	-0.035	0.360	-0.059	-0.287	0.078	0.022	-0.238	-0.010	0.035
Cu	0.154	0.253	0.356	-0.072	-0.171	0.037	-0.050	-0.059	-0.081	-0.076
W	0.168	0.088	-0.111	0.481	-0.223	-0.047	-0.116	0.055	0.067	-0.002
Cd	0.180	0.124	-0.102	0.449	-0.105	-0.143	-0.067	0.072	-0.046	-0.015
Be	-0.035	0.137	-0.070	0.396	-0.273	0.266	-0.105	0.255	0.103	0.039
Mo	0.020	-0.022	0.171	0.092	0.372	-0.346	0.084	-0.145	0.109	0.249
S	-0.125	0.121	0.249	0.126	0.067	-0.069	0.440	-0.020	0.046	0.029
Ti	0.084	0.209	0.009	0.197	0.167	0.312	0.397	-0.176	0.200	0.194
Ag	0.062	-0.027	0.083	-0.007	0.069	-0.179	0.241	0.658	-0.099	-0.283
Cr	0.107	0.123	-0.140	-0.278	-0.188	-0.106	-0.006	0.153	0.500	0.441
Bi	0.092	0.040	0.034	0.034	0.183	0.088	-0.386	0.153	-0.479	0.552
Au	0.029	0.016	0.265	0.009	-0.013	-0.004	0.191	0.369	-0.005	0.196
Sb	0.060	0.093	-0.011	0.284	0.141	-0.410	-0.136	-0.319	0.034	0.018
Pb	0.087	0.062	0.215	-0.033	0.218	-0.258	-0.291	0.104	0.350	-0.263

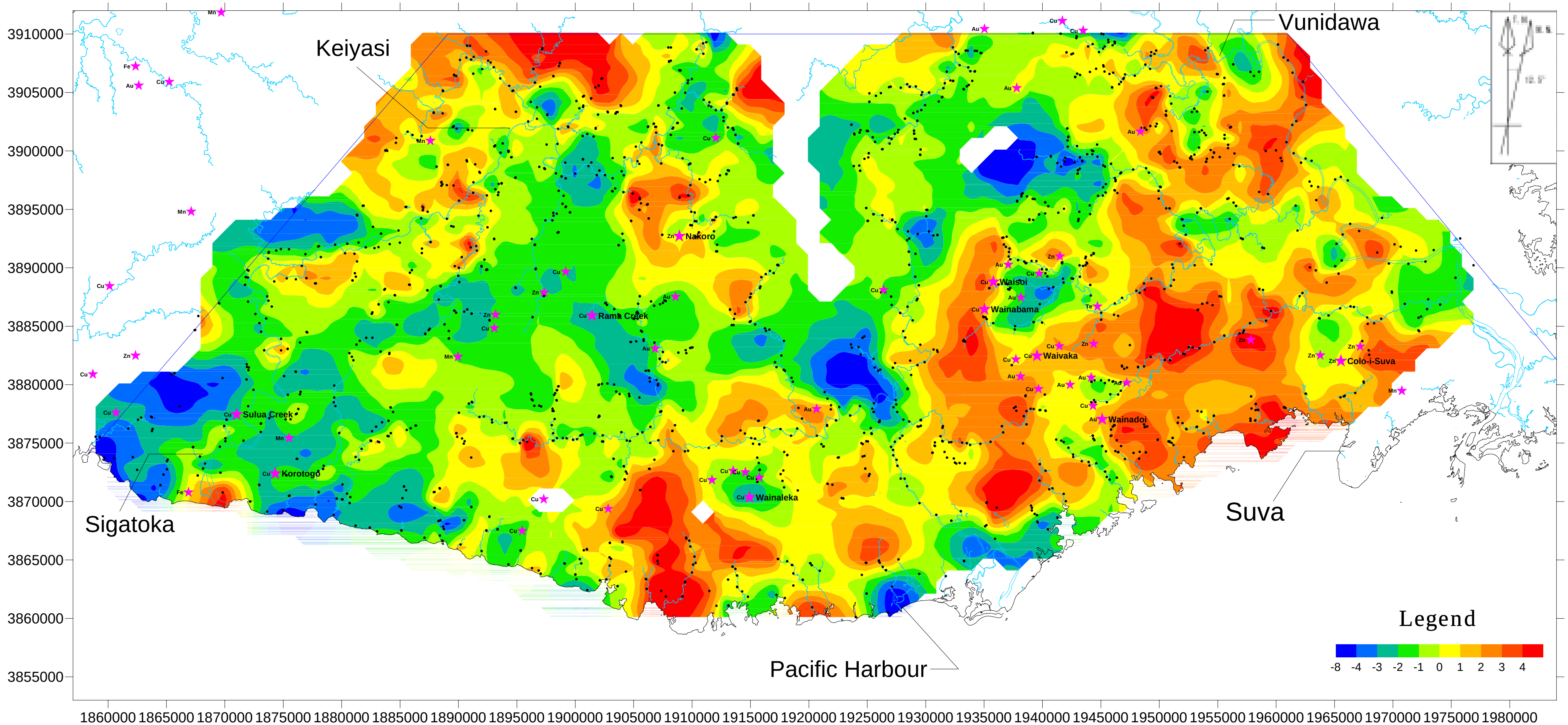

Figure II-1-4-(1) PCA score contour map of geochemical analysis of stream sediment samples (Z-1) (1:500,000)

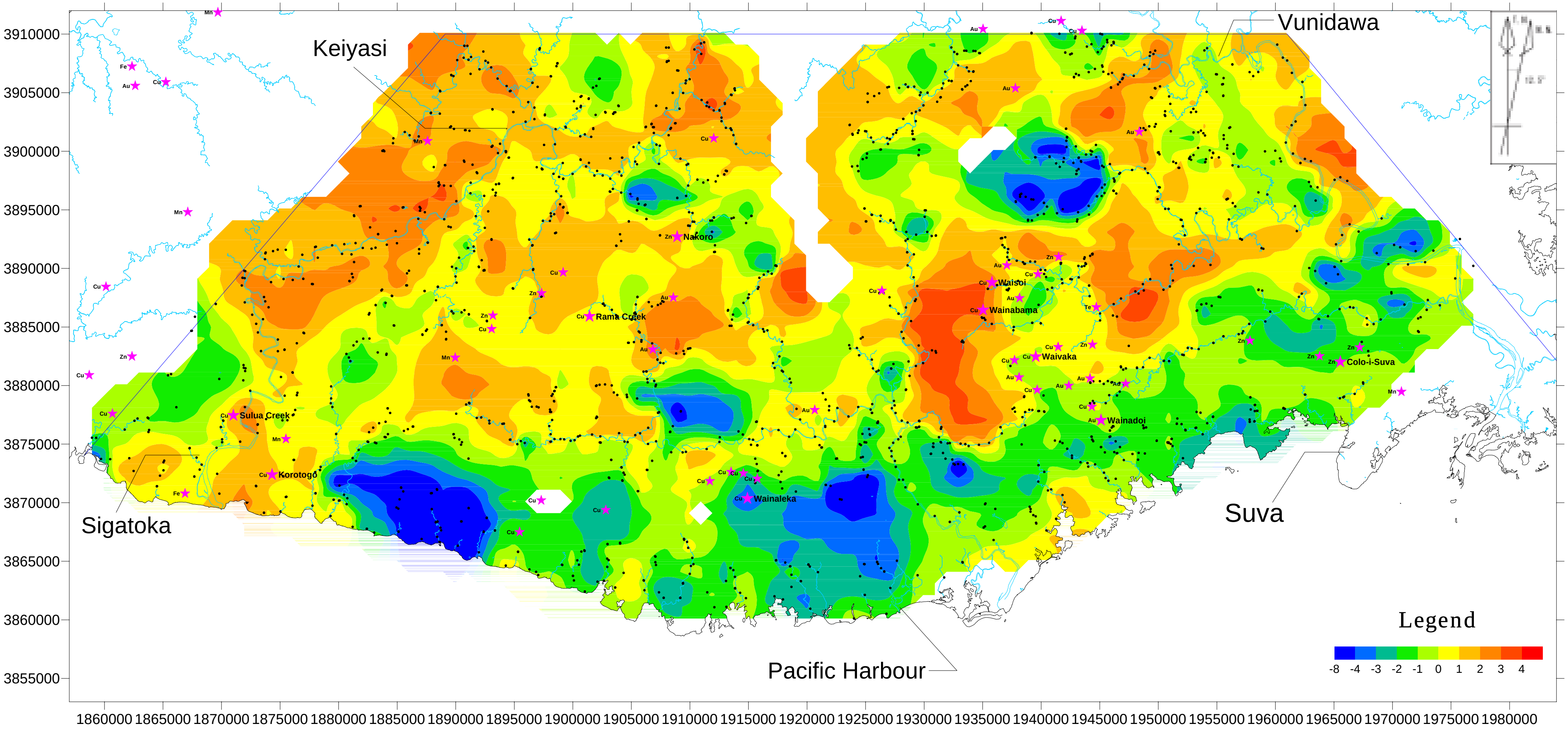

Figure II-1-4-(2) PCA score contour map of geochemical analysis of stream sediment samples (Z-2) (1:500,000)

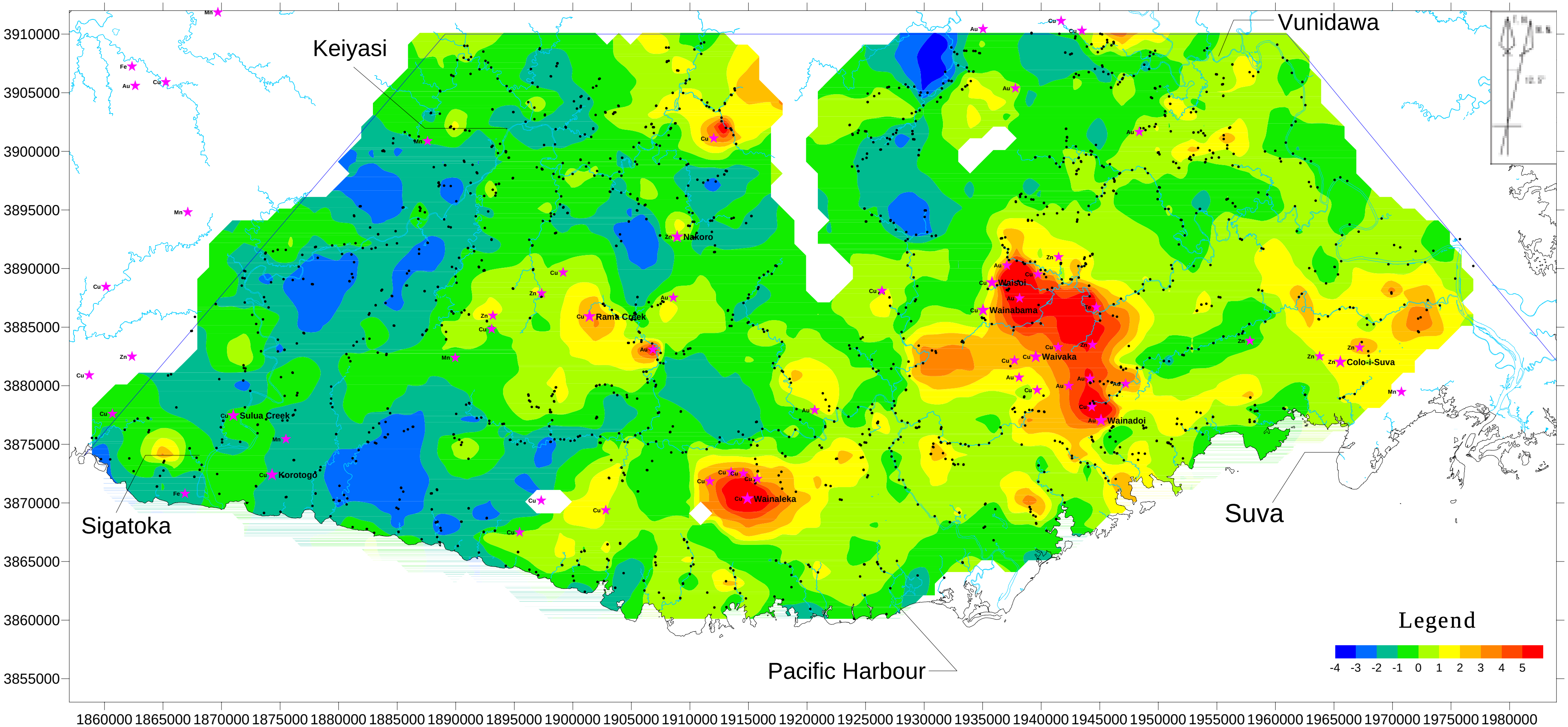

Figure II-1-4-(3) PCA score contour map of geochemical analysis of stream sediment samples (Z-3) (1:500,000)

Table II-1-5 Basic statistics of stream sediment samples from each drainage system

Elements	Unit	Detection limit	Rewa R. System				Navua R. System				Sigatoka R. System				Coastal R. System			
			Under detection limit(%)	Max value	Minimum value	Log. Average (m)	Under detection limit(%)	Max value	Minimum value	Log. Average (m)	Under detection limit(%)	Max value	Minimum value	Log. Average (m)	Under detection limit(%)	Max value	Minimum value	Log. Average (m)
Au	ppm	0.001	51.786	9.14	0.0005	0.0017	55.581	0.575	0.0005	0.0012	48.555	0.598	0.0005	0.0012	56.548	5.49	0.0005	0.0015
Hg	ppm	0.01	20.714	0.36	0.005	0.0111	17.209	0.07	0.005	0.0105	65.896	0.42	0.005	0.0066	21.726	0.15	0.005	0.011
Ag	ppm	0.5	98.036	1.6	0.25	0.255	99.535	9	0.25	0.2533	97.881	1.3	0.25	0.2562	97.321	0.7	0.25	0.2555
Al	%	0.01	0	12.25	2.08	5.5201	0	11.15	2.52	6.3718	0	9.48	0.79	6.1216	0	13.25	1.76	5.8226
As	ppm	5	83.75	105	2.5	3.1536	85.116	41	2.5	2.9817	91.522	84	2.5	2.7658	91.964	43	2.5	2.7122
Ba	ppm	10	0.7143	570	5	106.37	0	270	20	81.457	0	570	20	97.248	0.2976	200	5	54.278
Be	ppm	0.5	34.286	3.1	0.25	0.6548	53.953	3.2	0.25	0.4375	47.013	7.4	0.25	0.552	55.06	2.2	0.25	0.4146
Bi	ppm	2	77.143	32	1	1.4155	82.093	17	1	1.2709	69.942	16	1	1.4865	76.488	10	1	1.3361
Ca	%	0.01	0	4.71	0.09	1.3444	0	6.24	0.15	1.4408	0	11.55	0.6	2.7839	0	21.7	0.15	1.3208
Cd	ppm	0.5	67.143	8.8	0.25	0.4506	59.07	10.4	0.25	0.5262	48.748	14.8	0.25	0.742	66.369	6.9	0.25	0.4427
Co	ppm	1	0	138	2	29.919	0	108	5	28.579	0	132	7	34.112	0	118	1	25.078
Cr	ppm	1	0	5010	19	193.36	0	4290	12	187.99	0	2130	18	152.29	0	2970	9	126.62
Cu	ppm	1	0	1100	4	47.638	0	169	2	38.969	0	711	6	32.395	0.2976	158	0.5	25.996
Fe	%	0.01	0	25	2.15	14.296	0	25	4.24	11.951	0	25	3.75	12.725	0	25	0.59	11.919
K	%	0.01	0	1.71	0.06	0.4997	0	2.16	0.06	0.4199	0	2.43	0.07	0.5009	0	1.04	0.04	0.2596
Mg	%	0.01	0	3.73	0.14	1.166	0	3.57	0.17	1.2403	0	4.91	0.22	1.6551	0	3.44	0.07	0.9694
Mn	ppm	5	0	5020	404	2045.1	0	5350	450	1806.3	0	10000	613	1782.3	0	6740	174	1995.3
Mo	ppm	1	62.679	29	0.5	0.8321	54.884	23	0.5	0.9876	63.969	11	0.5	0.7716	67.56	9	0.5	0.7405
Na	%	0.01	0	2.91	0.1	0.8158	0	3.08	0.13	0.9673	0	3.67	0.18	1.2242	0	3.68	0.03	0.8931
Ni	ppm	1	4.2857	161	0.5	16.257	0.2326	110	0.5	22.527	0.1927	98	0.5	23.691	0.2976	85	0.5	15.689
P	ppm	10	12.679	1100	5	119.93	7.907	1080	5	140.92	6.5511	2140	5	161.65	21.726	570	5	44.847
Pb	ppm	2	14.821	38	1	5.1468	28.14	174	1	4.1533	22.351	35	1	4.1316	28.571	44	1	3.8043
S	%	0.01	37.143	2.66	0.005	0.0179	24.419	2.37	0.005	0.015	37.572	7.15	0.005	0.0132	46.429	2.76	0.005	0.0118
Sb	ppm	5	85	25	2.5	3.0133	70.698	22	2.5	3.584	65.125	24	2.5	3.9438	74.405	17	2.5	3.312
Sr	ppm	1	0.1786	421	0.5	98.729	0.6977	701	0.5	92.307	0.9634	1072	0.5	163.83	5.9524	4770	0.5	49.8
Ti	%	0.01	0	2.18	0.19	0.825	0	1.71	0.26	0.7949	0	1.82	0.2	0.8242	0	1.89	0.11	0.6926
V	ppm	1	0	2030	50	500.13	0	1920	58	418.89	0	1985	91	514.17	0	2540	14	370.03
W	ppm	10	55	20	5	7.3841	61.628	30	5	6.8	53.757	30	5	7.3963	58.333	30	5	7.1826
Zn	ppm	2	0	1440	21	181.16	0	741	36	168.06	0	889	52	168.03	0	936	18	181.09

Valid sample number : 1845 Rewa: 560 Navua: 430 Sigatoka: 519 Coastal: 336

Value under detection limit is represented by half value of detection limit

Value over upper detection limit is represented by upper detection limit