Proceedings World Geothermal Congress 2000
Kyushu - Tohoku, Japan, May 28 - June 10, 2000

THERMAL HISTORY OF MATALOKO AREA, FLORES ISLAND, INDONESIA

Isao Takashima[1], Asnawir Nasution[2] and Hirofumi Muraoka[3]
[1]Akita University, 1-1 Tegatagakuen, Akita 010-8502, Japan
[2]Volcanological Survey of Indonesia, Jalan Diponegoro No.57, Bandung 40122, Indonesia
[3]Geological Survey of Japan, 1-1-3 Higashi, Tsukuba, Ibaraki 305-8567, Japan

Key words: alteration, thermoluminescence dating, Mataloko area, Indonesia

ABSTRACT

Mataloko and nearby Nage geothermal areas are studied by X-ray diffraction, chemical analyses and thermoluminescence (TL) dating. Acidic white colored alteration halos are developed in both areas and thermal manifestations are predominant. Altered minerals found in these areas are quartz, cristobalite, tridymite, sericite, kaolinite, montmorillonite, alunite, sulfur and glass. Reacting fluid temperature is higher in Nage than Mataloko. Chemically, many silicified zones in both areas have high silica contents. Ages of volcanic and altered rocks were determined by TL method. Age range of 9 volcanic rocks is 31.5ka to 160ka. Stratigraphical correlation has not yet been done but all ages are young enough for geothermal development. Alteration ages also indicate the same range from 36.8ka to 183ka for 6 samples. It is also a good range for reserving heat beneath the area. However, age of alteration has a problem about chemical leaching of U, Th and K.

1. INTRODUCTION

Many geothermal fields are recognized in Indonesia. Mataloko area is one of them and studied by "Research Cooperation Project on the Exploration of Small-scale Geothermal Resources in the Eastern Part of Indonesia" (Muraoka et al, 1998). Mataloko and nearby Nage areas are characterized by thermal manifestations, such as steaming ground, fumaroles, hot spring and altered ground. Thermal activity is actually recognized at present but age of incipience and change in mode of activity have been not known yet.

We try to get such information by measuring alteration minerals, chemistry and ages of volcanic rocks and altered rocks. However, basic geology and precise alteration are not clear. Accordingly, we present preliminary data to consider about the above thermal history. Figure 1 is the location of study.

2. OUTLINE OF GEOTHERMAL ACTIVITY AND ALTERATION

Mataloko and Nage have fumaroles and hot springs over 90°C. White colored acidic alteration halos developed along the river (Figure 2). Total heat output is not measured yet but very high at Nage because the river water temperature is up to over 40°C.

Alteration minerals detected in both areas are shown in Table 1. Expected temperature forming alteration halo is high in Nage because much silicified zone (quartz zone) is developed. Rich in cristobalite in Mataloko indicates the low formation temperature. The names of Rokolaba and Wolo Bobo are not shown in Figure 2 but occurred as secondary materials in deposits. It indicates the alteration rocks near both areas.

Chemically, altered rocks divided into two types. One is silicified and the other is Al_2O_3 rich clay bearing rocks. Sulfur is not so common constituent. Measurement is done by EDX system with reference curve method. The data is semi quantitative but useful for alteration analysis.

More detailed consideration for both mineral and chemistry will be done in near future.

3. THERMOLUMINESCENCE DATING

Reliable TL age can be obtained only by the measurement of quartz. Samples for TL age determination were collected from both volcanic and altered rocks. Locations for such samples are shown in Figure 2. We collected many samples but only 9 samples can get results for determining volcanic events and 6 for alteration events. The reason for limitation of number is few acidic volcanic rock here and quartz content is low in most of altered rocks.

No Quaternary age data had been reported in this area. Published geologic map is 1:250,000 (Koesoemadinata et al., 1994) and only classifies Quaternary volcanic rocks and Mt Ineri lava. We can not decide geologic unit yet. All samples for age determination are collected near and surrounding the geothermal areas and give the rough idea of heat source volcanoes.

Samples for alteration age determination are 2 from Mataloko and 4 from Nage. All of them are white colored altered rocks and contain quartz.

Procedure for TL dating was followed by previous paper (Takashima and Watanabe, 1994). It consists of quartz separation, gamma ray irradiation, photo emission (glow) measurement and chemical analysis of radiometric elements U, Th, K). Figure 3 is TL glow patterns. By the graphical procedure, paleodose is calculated (Figure 4). TL age is simply calculated from this paleodose and annual dose which is determined by the contents of U, Th, K.

Table 2 is the results of TL ages for both volcanic and altered rocks.

4. AGE OF VOLCANIC ROCKS

Ages of 9 volcanic rocks include mud flow layer and range from 31.5ka to 160ka. All of them are prospective range for heat source of geothermal fields. Rough description of them are as follows;

V1 sample (132ka): Collected from Nage area. Lava of pyroxene andesite with minor quartz in groundmass.

V2 sample (123k): Rhyolitic pumice in pumice and pyroclastic flow deposit along the roadside of Rakalaba. Some possibility is affected by altered age because the upper part is

silicified altered rock.

V3 sample (145ka): Altered rock fragment in mud flow deposit in Nage area. It is not directly show deposit age but that of source rock. Accordingly, the formation age is younger than this figure.

V4 sample (156ka): Matrix part of same formation of V3 samples. The meaning of this data is the same as V3 samples.

V5 sample (89.8ka): Dacitic lava from Nage area. Upper part of the outcrop is silicified rock but no alteration effect to this sample.

V6 sample (31.5ka): Andesite rock fragment of basaltic pyroclastic flow deposit at south of Nage geothermal area. Eruption center of this flow is unknown but the youngest in all samples measured in this study.

V7 sample (82.2ka): Andesite fragment of phreato-magmatic deposit near summit of Mt. Wolo Bobo.

V8 sample (160ka): Andesite fragment from pyroclastic flow deposite at the foot of Mt. Wolo Lele.

V9 sample (98.2ka): Andesite lava from northwestof Bajawa. Thick lava flow is crops out at this point.

The age data must be compared with the startigraphical and volume estimation. It will be done in the next step.

5. AGE OF ALTERED ROCKS

Ages of altered rocks are 36.8ka to 183ka and almost same range as volcanic rocks. Sample are roughly described as follows;

A1 sample (87.2ka): Silicified rock from Mataloko area. The age must be younger because annual dose is too low to get meaningful age. It will be caused by chemical leaching of U, Th and K.

A2 sample (183ka): Kaolinite altered rock from Mataloko area. The meaning for this sample is the same as A1 sample.

A3 sample (172k): Silicified rock from Nage area. This age is also changeable for younger side.

A4 sample (36.8ka): Similar sample to A3 collected from the same area. This sample shows the youngest age in all samples but must be younger because annual dose is too low.

A5 sample (173ka) and A6 samples (76.2ka): Both of them were collected from silicified altered zone at Nage area. Both sample must be the same age but A5 sample is older than A6 sample. It means that most of altered samples leached out U, Th and K after forming alteration rocks.

The youngest age is found at Nage area. It also coincides with ages of volcanic rocks. The data indicates that the hydrothermal activity follows volcanic eruptions near by.

However, a big problem remained for TL age determination of altered rocks because they tend to be leached out U, Th and K.

6. CONCLUSIONS

Alteration minerals identified are quartz, cristobalite, tridymite, sericite, kaolinite, montmorillonite, alunite, sulfur and glass. Fluid temperature is expected higher in Nage than Mataloko.

Ages of volcanic rocks range from 31.5ka to 160ka. All of them are suitable for heat supply to geothermal system. Correlation with geology is the next important study.

Alteration took place simultaneously as volcanic eruption. However, getting reliable alteration age is big problem for the future because altered rocks tend to be leached out U, Th and K after alteration.

ACKNOWLEDGEMENTS

This work is financialy supported by New Sunshine Headquaters, the Agency of Industrial Science and Technology. We thanks for help for field survey by many colleagues of the Volcanological Survey of Indonesia. We also thanks for help for joint research work to the New Energy and Industrial Technology Developmment Organization.

REFERENCES

Koesoemadinata, S. Noya, Y. and Kadarisman, D. (1994). Geological map of the Ruteng Quadrangle, Nusa Tenggara, - scale 1:250,000. Geological Research and Development Centre, Indonesia.

Muraoka, H., Nasution, A., Urai, M. and Takahashi, M. (1998). A start of “Research Cooperation Project on Exploration of Small-scale Geothermal Resources in Remote Island in Indonesia”. Chisitsu News, No.521, pp.34-48 (In Japanese).

Takashima, I. and Watanabe, K. (1994). Thermoluninescence Age Determination of Lava Flows/Domes and Collapsed Materials at Unzen Volcano, SW Japan. Bull. Volcanol. Soc.. Japan, Vol.39, pp.1-12.

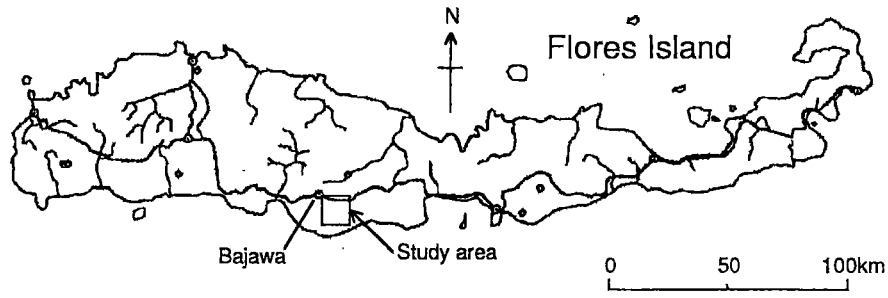

Figure 1. Location of study area include Mataloko and Nage geothermal fields.

Table 1. Secondary minerals and chemistry of altered rocks from geothermal areas.

	Mataloko area										
No.	IN98071301G	IN98071301	IN98071501	IN98071502	IN98071503A	IN98071503B	IN98071505	IN98071506A	IN98071506B	IN98071507	IN98071508
Mineral*	Cr,(Gl)	Cr,Q	Cr,(Gl)	Tr,Cr,K	Q,Cr,K	Q,K,M	M,Q,K	Cr,K	A,Cr,K	Q,S,(Gl)	Q,Se,K
$SiO_{2\ wt\%}$	108.29	95.27	94.65	86.59	71.05	63.25	60.92	64.08	54.41	90.40	57.24
TiO_2	1.15	1.45	1.47	2.43	1.48	1.54	1.28	1.40	0.79	2.56	1.20
Al_2O_3	2.15	2.35	3.97	12.78	24.90	28.13	24.91	31.11	28.04	3.15	32.00
Fe_2O_3**	0	0	0	1.32	1.90	3.06	10.60	4.74	0.81	0	12.50
MnO	0	0	0	0.04	0.05	0.09	0.12	0.05	0	0	0.08
MgO	0	0	0	0	1.94	2.27	3.59	1.01	0.42	0	1.29
CaO	0.01	0.29	0.01	0.21	0.53	0.64	1.12	0.18	0.24	0.01	0.42
Na_2O	0	0	0	0	0	0	0	0	0	0	0
K_2O	0.06	0.08	0.11	0.09	0.08	0.08	0.10	0.13	3.53	0.08	0.10
S	2.32	0	0.19	0	0	0	0	0.33	16.09	14.9	0
Total	113.98	99.44	100.40	103.46	101.93	99.06	102.64	103.03	104.33	111.10	104.83

	Rokolaba area		Nage area								Wolo Bobo area
No.	IN98071509A	IN98071509B	IN98071601	IN98071602	IN98071603A	IN98071603B	IN98071604A	IN98071604B	IN98071605A	IN98071606	IN98071701D
Mineral*	Cr,(Gl)	Cr,(Gl)	Q	Q	Q	Q	Q,Cr,K,A	Q,A	Q	Q,Tr,Se,K	Cr,A,(Gl)
$SiO_{2\ wt\%}$	103.17	102.67	88.89	89.78	103.53	100.15	58.06	85.90	90.51	72.18	84.25
TiO_2	2.82	2.66	2.04	0.45	2.09	1.33	1.03	1.96	0.59	1.46	1.31
Al_2O_3	2.53	2.09	1.34	0.63	1.29	2.20	22.16	5.95	0.89	32.82	7.93
Fe_2O_3**	0	0	0	0	2.40	0	2.93	0.09	0	1.46	0
MnO	0	0	0	0	0.03	0	0	0	0	0.01	0
MgO	0	0	0	0	0	0	0.28	0	0	1.39	0
CaO	0.01	0	0	0	0	0	0.01	0.19	0	0.10	0.23
Na_2O	0	0	0	0	0	0	0	0	0	0	0.01
K_2O	0.06	0.06	0.06	0.06	0.06	0.06	0.58	0.21	0.06	0.13	1.25
S	0.87	0.15	0	0	0	0	8.59	3.18	0	0.57	4.07
Total	109.46	107.63	92.33	90.92	109.40	103.74	93.64	97.48	92.05	110.12	99.05

*Abbriviation of minerals; Q:Quartz, Cr:Cristobalite, Tr:Tridymite, Se:Sericite, K:Kaolinite, M:Montmorillonite, A:Alunite, S:Sulfur, (Gl):Glass **Total iron as Fe_2O_3

Table 2. TL ages of volcanic and altered rocks.

No.	Sample No.	U (ppm)	Th (ppm)	K2O (%)	Annual dose (mGy/a)	Paleodose (Gy)	TL age (ka)	Remarks
	(Volcanic rocks)							
V1	IN98071401	1.64	7.76	1.27	1.91	252	132	
V2	IN98071510	0.49	4.83	0.20	0.610	75.0	123	
V3	IN98071604A	1.25	5.33	2.10	2.29	332	145	Altered rock block
V4	IN98071604B	1.70	7.67	0.69	1.46	228	156	Mud flow matrix
V5	IN98071605B	4.52	19.43	2.86	4.62	415	89.8	
V6	IN98071607	2.01	8.93	1.77	2.46	77.4	31.5	
V7	IN98071701A	2.09	10.13	1.59	2.42	199	82.2	
V8	IN98071702B	1.79	7.28	1.34	1.96	313	160	
V9	IN98071703C	1.49	7.20	1.13	1.72	169	98.2	
	(Altered rocks)							
A1	IN98071301	0.51	1.80	0.08	0.321	28.0	87.2	
A2	IN98071503A	0.34	2.66	0.08	0.344	62.8	183	
A3	IN98071601A	1.24	3.44	0.06	0.598	103	172	
A4	IN98071602	0.33	0.77	0.06	0.185	6.8	36.8	
A5	IN98071603A	2.23	5.20	0.06	0.962	166	173	
A6	IN98071603B	2.50	7.17	0.06	1.17	89.2	76.2	

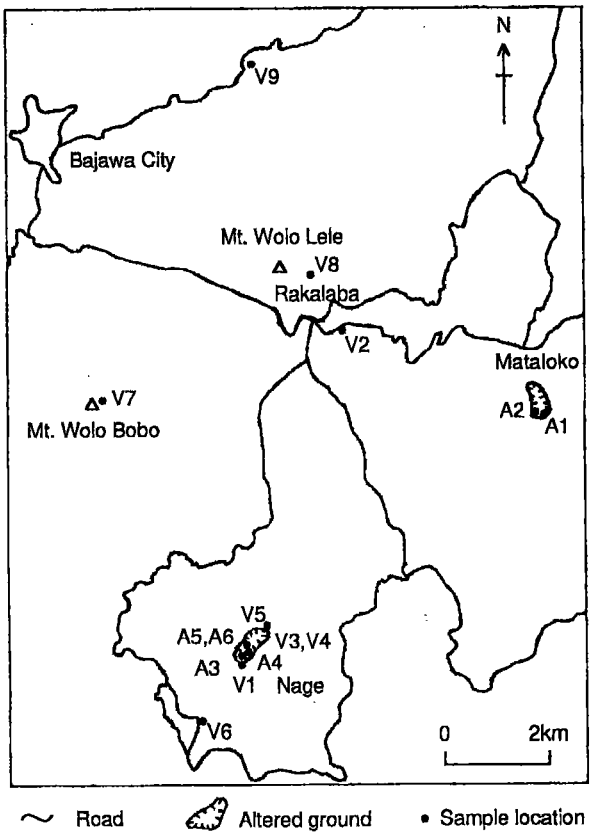

Figure 2. Location of samples for TL dating and altered ground.

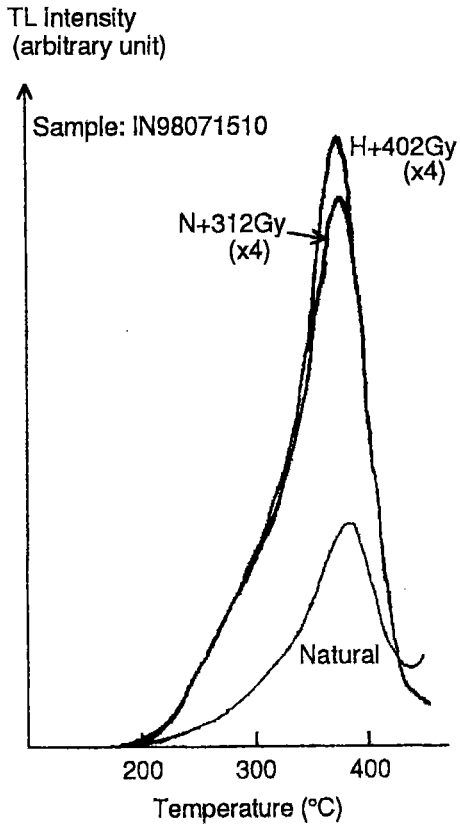

Figure 3. TL glow curves for quartz separated from volcanic rock.

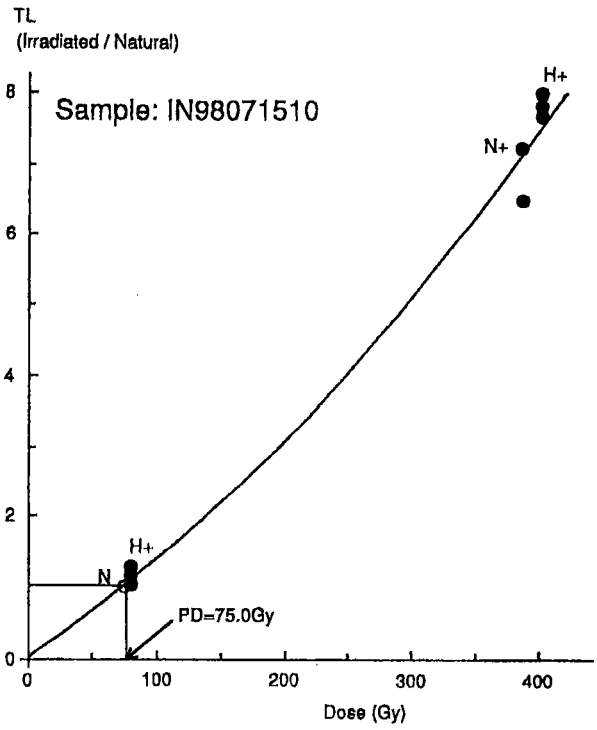

Figure 4. TL growth curve of volcanic rock.