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CHARACTERISTICS OF GEOTHERMAL RESOURCES OF THAILAND AND THEIR FUTURE DEVELOPMENT STRATEGY

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ABSTRACT

Geothermal systems of Thailand is reviewed from the viewpoints of geology, chemistry, heat source, exploration well data, etc. Detailed discussion of heat source evaluation and possibility of apply of SAR image data analyses to geothermal exploration are carried out. Based on the character of geothermal resources, strategy for exploration and development, that focus on shallow reservoir and practical use are presented. For the future development plan, use of near-surface to shallow heat extraction is strongly recommended.

1. INTRODUCTION

Geothermal resources of Thailand is known as non-volcanic origin but many high temperature hot springs are recognized. Many research works and exploration projects were done and outline of geothermal system is defined. However, geothermal exploration and development in Thailand is now inactive because high temperature resources not found even deep drillings.

In this paper, we review such works. Then original data of heat source evaluation and structure analyses using JERS-1 SAR imagery for a tool of geothermal exploration. Finally, future development strategy will be proposed for medium temperature resources and shallow heat extraction for air condition etc.

2. CHARACTERISTICS OF GEOTHERMA FIELDS

More than 90 hot springs with surface temperature range of 40-100 °C are scattered in whole Thailand (Ramingwong et al., 2000). Hot spring waters characterized by low dissolved materials with quite similar chemical features with exception of seashore area (Table 1). Estimated temperature by chemical geo-thermometer also not so high (<200°C).

Isotopic data of hot water indicate that the origin is meteoric. From such data, deep circulated system is inferred. Generalized model was presented by Sasada (1982, unpublished; referred by Chuaviroj, 1988) as shown in Fig. 1. Similar but more geophysical model was presented by Hochstein and Caldwell (1985).

At present, heat source is considered granitic rock with high radiometric elements. Kawada et al. (1987) was carred out preliminary evaluation of heat from granitic rocks. More detailed result of this heat contribution is described in chapter 4.

Now we have common idea that the deep circulating water is come up along the fault. Reservoir may confirmed by simple channel like shape which allows low dissolved solids (Takashima and Jarach, 1987). Actual subsurface temperatures were proved in some areas by drilling (Table 2) but not maximum temperature encountered was 130°C at bottom hole (>414m) of FX-4 at Fang area (Ramingwong et al., 2000).

Table 1 Representative chemical data of hot spring waters in Thailand (after Peangkeaw, 1999).

Location	Surface temp(C)	Subsurface temp(C)	pH	TDS	Sulfide sat. (mg/l H_2S)	Na	K	Ca	MG (mg/l)	SiO_2	Cl	F	SO_4
1.San Kamphaeng/Chiangmai	92	145	9.38	570	[illegible]	152	13	0.9	nil	139	[illegible]	15.4	55.8
2.Fang/Chiangmai	90	164	9.45	540	nil	131	9.2	1.1	0.05	188	[illegible]	21.7	45.3
3.Tepanom/Chiangmai	95	143	9	415	[illegible]	105	6.7	3	nil	113	1	10	5
4.Ban Pong/Chiangmai	80.3	121	8.43	460	nil	143	7.5	7	0.56	77	4.5	6.3	16.5
5.Nong Krok/Chiangmai	72.3	119	7.1	560	nil	168	11	19	3.32	77	2.5	5	14
6.Mae Chan/Chiangrai	99	159	8.6	550	nil	138	8.1	1.6	0.03	169	[illegible]	nd	53
7.Wieng Papao/Chiangrai	92	137	8.9	390	[illegible]	90.9	8.4	3.2	0.02	109	[illegible]	11	6.2
8.Chaeson/Lampang	78	138	7.3	440	[illegible]	116	11	4.6	0.27	113	[illegible]	3.7	22
9.Pong Namrong/Lampang	60	98	8.8	330	nil	80	5.3	9.4	1.3	45	3.5	nd	3
10.Pa Pae/Mae Hong Son	93	127	8.6	350	[illegible]	96	4.5	5.3	0.13	90	[illegible]	nd	32
11.Pong Nam Ron/Mae Hong Son	95	122	8.4	360	[illegible]	110	4.5	5	0.04	80	[illegible]	nd	24
12.Mae Chok/Phae	69	130	7.28	680	nil	194	21	24	0.75	95	[illegible]	7.17	62.8
13.Nongliom/Lamphun	42.4	91	7.7	355	[illegible]	95.4	6.7	25	1.3	38	[illegible]	3.6	12.1
14.Namron/Phetchabun	52	118	9.35	255	–	67.5	1.2	1.4	nil	72	[illegible]	1.4	34.2
15.Tamaidaeng/kamphaengphet	54	109	8.13	410	–	129	4.7	5.1	0.05	59	[illegible]	8.3	25.1
16.Chaiya/Surathani*	65	106	6.8	12,870	–	3.95	147	76	[illegible]	55	[illegible]	0.01	787
17.Ampoe Muang/Ranong	65	123	7.8	300	–	71.5	4	21	0.17	80	[illegible]	0.02	21.2

* Exposed near the seashore (after Thienprasert et al, 1986)

Table 2 Summary of exploration drilling for geothermal resources in northern Thailand (after Ramingwong et al., 2000; original data from Praserdvigai, 1997).

Year / Organization	Geothermal Area	Dept of Well (m)	No. of Wells	Remark
1981-1987/EGAT	San Kampaeng	<100	40	The development project was postponed.
		<500	6	
		1,227	1	
		1,300	1	
1981-1995/EGAT	Fang	<100	27	A 300 KWH binary cycle power plant is under operation. Deep reservoir exploration was postponed.
		<200	7	
		<150	10	
		<500	3	
1984/DMR	Pong Kum	20-50	50	
	Ban Sop Pong	20-50	16	
	Ban Pong	150	1	
	Ban Nong Krok	120	1	
	Ban Mae Chok	100	1	
	Ban Pun Jane	100	1	
1994/DEDP	Tepanom	100	3	Geysering well
	Pong Pu Fuang	100	2	
	Koh Kha	101	1	
1995/DEDP	Mae Kasa	100	1	
	Nong Haeng	100	2	
1996/EGAT	Pai (Muang Rae)	<50	10	Unfavourable reservoir temperatures.
	Pai (Muang Paeng)	<50	10	
1996/DEDP	Mae Chan	100	2	Geysering well
	Pha Sert	100	2	
1997/DEDP	Muang Ngam	100	2	
	Pha Bong	100	2	

Table 3 Summarized data of radiometric elements and heat generation in northern Thailand.

Area No.	Area	U (ppm)	Th (ppm)	K_2O (%)	Th/U	HG	HGU	Number of samples
1	North of San Kamphaeng	9.5 (3.1)	29.2 (5.3)	5.02 (0.26)	3.0	18.6	12.0	19
2	Pa Pao-Prao	10.2 (1.9)	32.2 (4.4)	4.87 (0.51)	3.2	19.7	12.6	10
3	Mae Chaem-Mae Sariang	14.1 (7.0)	49.3 (9.1)	5.66 (0.53)	3.5	28.1	18.1	8
4	Pa Pae-Chiang Dao	7.8 (1.8)	27.4 (2.0)	4.57 (0.45)	3.5	16.0	10.3	13
5	Fang-Chiang Rai	8.4 (0.8)	28.5 (1.3)	4.48 (0.23)	3.4	16.9	10.8	4
6	Chiang Rai-Mae Chan	12.3 (2.7)	43.8 (7.4)	4.46 (0.63)	3.6	24.6	15.8	8
7	Fang	7.5 (2.1)	19.1 (8.1)	4.00 (0.51)	2.5	13.4	8.6	7

HG: Heat generation (10^{-10} mW/g)
HGU: Heat generating unit ($0.42 \mu W/m^3$)
Figure in parenthesis indicates standard deviation

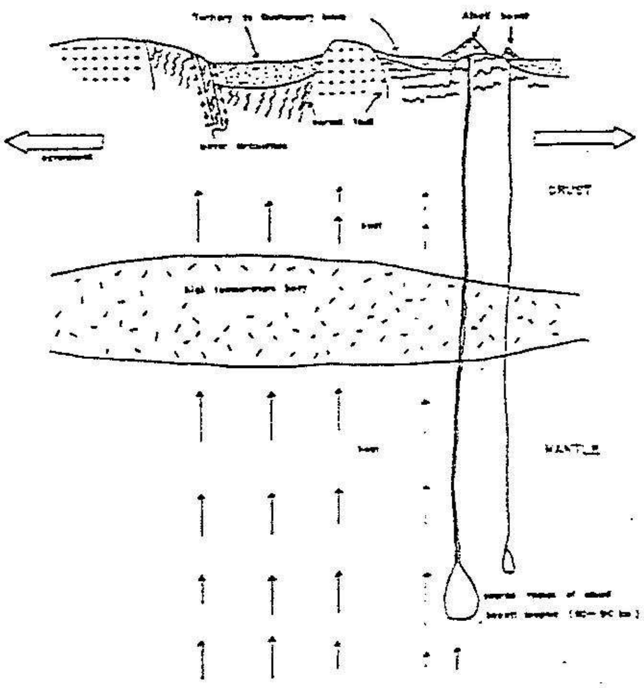

Fig. 1 Generalized tectonic geothermal model of Thailand (after Sasada, 1982, unpublished; Chuaviroj, 1988).

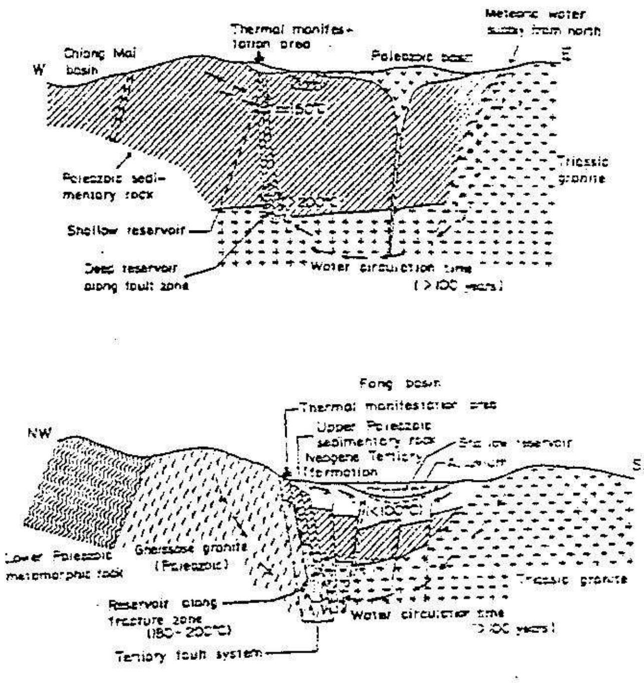

Fig. 2 Geothermal models of San Kamphaeng (upper) and Fang (lower) (modified from Takashima and Jarach, 1987).

3. GEOTHERMAL MODEL OF SAN KAMPHAENG AND FANG AREAS

Intensive study was done at San Kamphaeng and Fang areas, northern Thailand. The deepest well for geothermal exploration was drilled at San Kamphaeng and first geothermal power plant of 300kW binary system was constructed at Fang.

Combined with many exploration data, models of both areas presented (Fig.2). More detailed underground temperature distribution was also shown in Fig. 3. The highest temperature encountered was 120°C at the bottom of GTE-6 (500m) but not in deepest well GTE-7 (1000m). It is important that the high temperature zone is confined limited area along fault.

4. HEAT SOURCE EVALUATION

Most people believe that the heat source is decay heat of U, Th and K. We measured 69 granitic rocks collected from 7 areas shown in Fig.4. Analyses of the radiometric elements were carried out by gamma-ray spectrometry on 1024 channel analyzer with 75mmx75mm NaI(Tl) scintillation detector.

The results of analyses grouped into 7 areas were listed in Table 2. The data of each area was not so dispersed as shown in the figures of standard deviation. Figure 4 shows the geology and high heat flow areas with sampling localities. As shown in Table 2, two high heat generation unit (HGU) areas, Mae Chan - Mae Sariang (18.1HGU) and Chiang Rai -Mae Chan (15.8HGU) , were identified. There are no direct relation with these high HGU areas and hot spring distribution. However, heat from granitic rocks is largely contribute to the geothermal systems in Thailand.

Lachenbruch and Sass (1977) and Lachenbruch (1970) were introduced following two equations for heat and temperature evaluation.

$$Q = A_0 \cdot D + q \quad \text{------------------------------} (1)$$
$$\theta(z) = (q \cdot z + D^2 \cdot A_0 (1 - \exp(-z/D)))/K \quad \text{----} (2)$$

Where;

Q: Heat flow at the surface (HFU)

A_0: Heat generation of near surface rock (HGU)

D: Thickness of heat generating rock body (km)

q: Heat flow from mantle (HFU)

$\theta(z)$: Subsurface temperature at a depth "z" (°C)

K: Constant

Figure 5 is the relation of Q and A_0 at different q values and D=10km. Based on heat generation data and reported heat flow data (Thienprasert and Raksaskulwong, 1984), heat flow value from mantle is estimated around 0.8HFU in northern Thailand.

Figure 6 shows roughly estimated sub-surface temperature distribution patterns using the above heat flow data and equation (2). Depth reaches to 200°C is around 5km even if the heat flow is 2.6HFU. Chemical Geothermometer shows that the fluid temperature reaches to 200°C at maximum. This means that water circulate down to about 5 km.

5. LINEAMENT ANALYSES

We are now studying lineament of some areas in Thailand for active fault analyses and neo-tectonic evolution. The areas study are Fang - Mae Chan, Phrae and Tak. Main source for lineament analyses is JERS-1 SAR images. Aerophotographs and LANDSAT images also use for analyses.

The data for such study can apply to geothermal exploration because hot springs are closely related with faults. Figure 7 is the summarized map of Fang - Mae Chan area with information of succession of movement and origin of fracture systems. Detailed analyses for use it to geothermal exploration is not yet done but will become good data.

6. STRATERGY OF EXPLORATION AND DEVELOPMENT

As mentioned above, geothermal resources in Thailand is deep circulation origin and confined along the fault. In early stage of development, some drillings were done for getting high temperature reaches to 200°C which recorded by chemical geothermometer. Such high temperature is only reachable in depth to 5km. Accordingly, exploration and development is focus on shallow, intermediate temperature resources.

In exploration, application of some limited methods is enough., ex. geology, hot spring chemistry, resisitivity etc. Then make shallow hole for conform reservoir characters. It's recommendable to make many plan to use hot waters. If resources much enough binary power plant, think for construction it. If the resources is small, make heating plant for agriculture use. Important point is actual use of geothermal resource even if the resources is not large.

7. POSSIBILITY OF SHALLOW HEAT EXTRACTION SYSTEM

Very shallow (1-150m) heat extraction system is now widely used in Europe and US. It's very simple and no risks for search of resources. The size of individual use is very small but number of facility is so large. Accordingly, total contribution for energy save will be bigger than electricity production. Another advantage is the small budget for research and development.

In Thailand, main use will be air conditioning (cooling). For such purpose, first step will know the geologic (or soil) characters and temperature. The system for such study is very simple and easy. Figure 8 shows such system made at Akita University. We recommend to start same kind of study as soon as possible.

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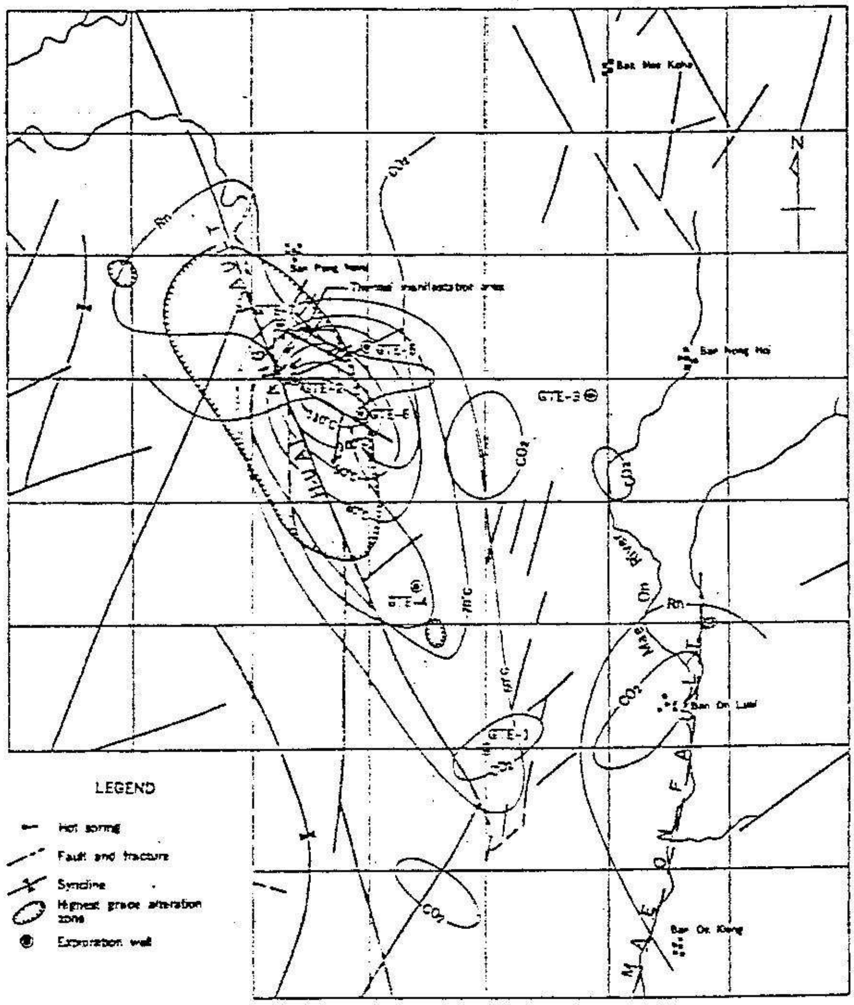

Fig. 3 Isotherm of 400m depth of San Kamphaeng area with some exploration data (modified from Charusiroj et al. (1987) with temperature data from Jivacate, 1985).

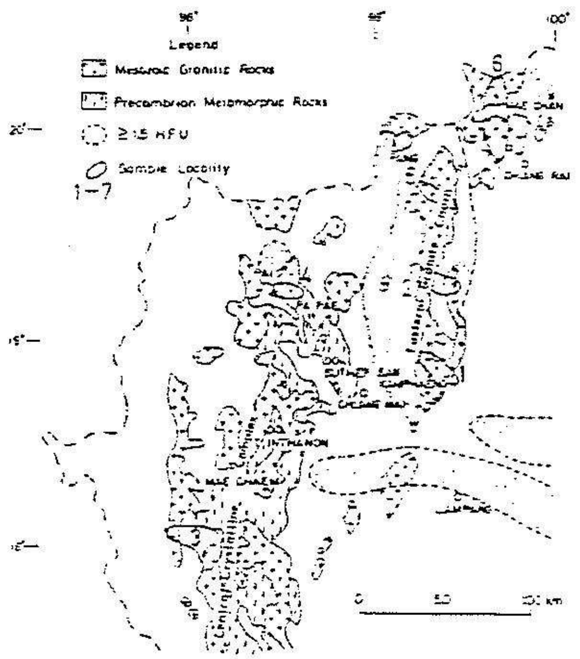

Fig. 4 Sampling areas for radiometric measurements with geology and heat flow data.

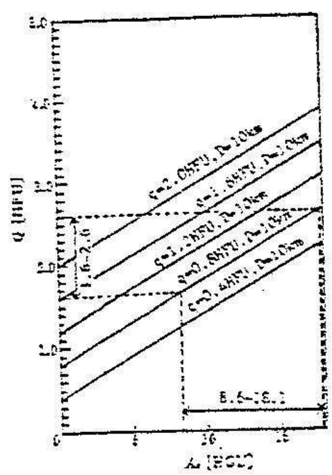

Fig. 5 Relation between heat generation unit (HGU) and heat flow unit (HFU).

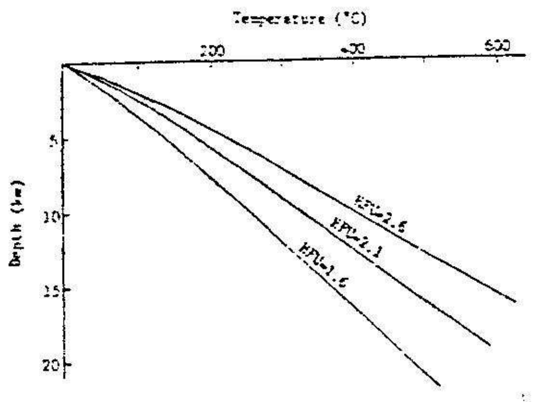

Fig. 6 Roughly estimated thermal gradient with different heat flow unit (HFU).

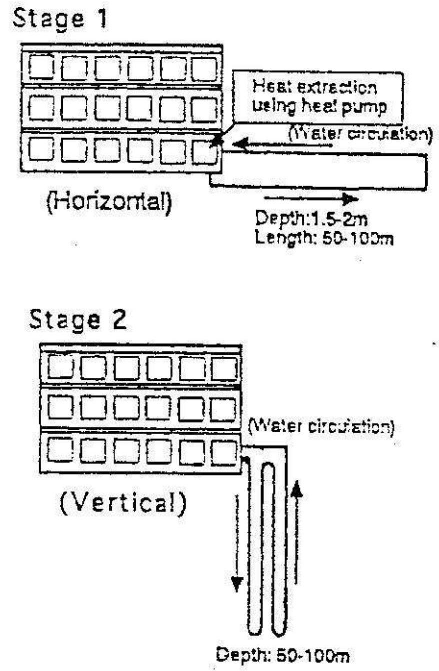

Fig. 8 Model for ~~sallow~~ shallow heat extraction experiment at Akita University.

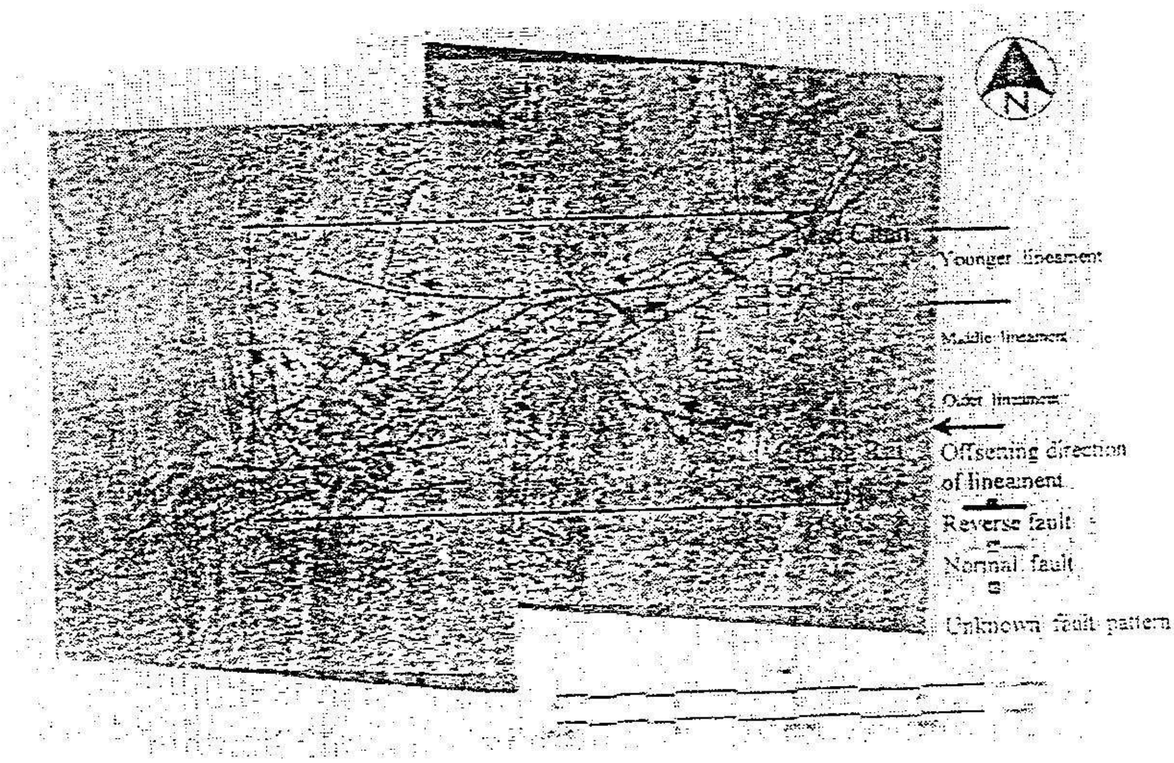

Fig. 7 Structual analyses of Fang - Mae Chan area by use of JERS-1 SAR images.