COUNTRY UPDATE OF GEOTHERMAL DEVELOPMENTS IN KOREA

Uk Han

Dept. of Environmental Sciences
Korea Military Academy
Seoul, Korea 139-799

Key words: Korea country update, thermal waters, district heating

ABSTRACT

This study updates geothermal energy developments in Korea. The attached tables 1, 2 and 3 represent the geothermal localities in South Korea, development of thermal water in North Korea, and the drilled-wells in South Korea respectively. Some of the basic information are additions to the previous papers.

Information is provided on the status of geothermal energy utilization in Korea, with emphasis on development from 1987 to 1994. A total of 276 sites, which respectively include 38 and 69 thermal springs in North and South Korea, have been identified with a low temperature energy use.

Thermal waters exploited from the Cretaceous Boolgooksa Granite and the Jurassic Daebo Granite have a certain degree of higher temperature. Sufficient vertical permeability at the intersection of faults or fractures leads to the formation of thermal springs. Geologic formations, structures and sediment thickness control the geothermal field. The thermal wells in South Korea are suitable for public baths, greenhouses and fish farming. The most remarkable and significant branch in North Korea is the balneological use and building heating related to the bathing complex and resorts.

INTRODUCTION

Historically, the geothermal energy in Korea was used by small resorts and baths. Since the 1980s, geothermal resources have been used in various ways. Tables 1, 2 and 3 are based on the extensive studies conducted by Han (1979a, 1979b, 1981a, 1981b, 1984, 1985, 1986, 1987, 1988a, 1988b, 1990, 1991, 1992, 1993), Koo et. al (1993) and Lee et. al (1986) for the Department of Home Affairs, Republic of Korea (1983, 1994), Taejon City, Provincial governments of Choongnam and Jeonbook, and the Korean Science and Engineering Foundations from 1985 to 1993 and updated in 1994.

Beginning in 1985, the provincial government of Choongnam initiated two research programs that also caused significant growth in the geothermal exploration. Geothermal energy utilization projects operate all over Korea, especially in Choongnam, Kyungbook, Kyungnam province and those provinces where the thermal water is low to moderate temperature. The great energy consumption is for baths and spars.

GEOTHERMAL LOCALITIES AND DEVELOPMENT

Geothermal potential exists in Korea for the development of thermal water for baths, spars, greenhouses, fish farming and a limited space heating. Thermal energy from low temperature geothermal systems is used almost exclusively for these applications. According to geologic environments and heat transfer regimes, low temperature thermal resources occur in two types of geothermal systems : (1) conduction dominated systems and (2) convection dominated systems. In conductive systems, there exist high thermal conductivity contrasts and thermal gradients of rocks vertically. These conditions occur beneath the sedimentary basins, such as Onyang, Doko and Yuseong areas. In convective systems, upward migration of water transports thermal energy to reservoirs at shallow depth. These systems occur in the areas of above-normal heat flow and active tectonic regimes, such as Donglae, Boogok, Baekahm in South Korea and Hambook province in North Korea.

Table 1 provides information about geothermal localities in Korea according to local provinces. The information in Table 1 relies on the geothermal data of Han (1979, 1981b, 1986b, 1987, 1988a, 1988b, 1989, 1993b) and Department of Home Affairs (1983, 1994). Table 2 is developed by consulting Baekwa Jeonsuh (1982), Bookhahn Chonglahm (1993) and geologic maps. Tables 1 and 2 contain characteristics of the reserviors classfied by geologic formations. Table 1 gives temperatures of 69 warm/hot springs in South Korea by each province. Average temperature increases from 29.5℃ in sedimentary/volcanic/metamorphic rock areas to 33.2℃ in the Cretaceous and Jurassic granite areas. The temperatures of reserviors have a mean value of 31.2℃ and range of 25-78℃. Table 2 lists temperatures of 28 warm/hot springs in North Korea by each province. Average temperature increases from 47.3℃ in metamorphic/sedimentary/volcanic rock areas to 55.2℃ in the Cretaceous and Jurassic granite areas. The temperatues of reserviors have a mean value of 51.0℃ and range of 35-78℃.

Thermal water is used for public or private baths and hotels, and is more quickly developed in 1980s in South Korea. There are a lot of baths, swimming pools and sanatoriums. Medical treatment and physical therapy using thermal water have shown special effects on many illnesses which can not be cured by modern medicine. However, most of baths and resort areas are owned by individuals and private companies excluding Sooahnbo hot spring. Recently, the swimming pools for athletic training have developed in Onyang hot spring area. In 1993, there are a few greenhouses in Kyungbook and Choongnam provinces. The products raised in these greenhouses include various fresh vegetables and potted flower plants. Small plastic pipes are used in the greenhouse complex to increase temperature 2-5℃. Fish farming with ground or thermal water is practiced widely in the southern and southeastern onshore parts of Korea. There are many fishing pools in Kyungbook, Kyungnam and Jeonnam provinces. The products include fish, shrimps, turtles, eels to snails and snakes.

Geothermal application for space heating is investigated by two research projects, (1) exploration and development of geothermal energy for space heating in Masan and Changweon area (1993), and (2) exploration and feasibility study for geothermal potential in Cheju Island (1994).

THERMAL WELLS DRILLED

Two hundred twenty nine thermal wells have been drilled during the period from 1987 to 1993, as summarized in Table 3. In addition to 229 wells in South Korea, there have been about additional 20,000 wells drilled throughout South Korea which are not documented, since they are classfied as cold water wells. Most of the wells are for production. The average depth of cold water wells is around 150m and the temperature is below 24℃. The mean and range of maximum depth of boreholes are 463.3m and 13-956m. Table 3 is developed by investigations of Han (1987, 1988a, 1988b, 1990, 1991, 1992, 1993, 1994) and KIER for lists of geothermal wells drilled since 1987.

TABLE 1 - INFORMATION ABOUT GEOTHERMAL LOCALITIES IN SOUTH KOREA

Rock[1] = Main type of reservoir rock.
TG - Triassic Granite
JG - Jurassic Granite
CG - Cretaceous Granite
S - Sedimentary Rock
MS - Metasedimentary Rock
M - Metamorphics
V - Volcanics

Water[2] = Total dissolved solids, in mg/kg, before flashing.
Categories : (1) < 1,000 mg/l (2) 1,000 to 10,000 mg/l
(3) > 10,000 mg/l

Status[3]
N = Identified geothermal locality, but no assessment information available
R = Regional assessment
P = Pre-feasibility studies
F = Feasibility studies
U = Commercial utilization

Year[4] = Official approval by Department of Home Affairs.

Locality	Location		Reservoir		Status[3]	Reservoir Temp. ℃ and (No. Systems)	Year[4] Approved
	Latitude (N)	Longitude (E)	Rock[1]	Water[2]			
Pusan							
Donglae	35 12.1	129 05.6	CG	L(2)	R, U	38-63 (33)	1981
Haewoondae	35 09.6	129 09.8	CG	L(2)	R, U	40-62 (9)	1981
Kyungnam							
Boogok	35 25.9	128 36.0	S	L(1)	R, U	54-78 (86)	1981
Maakeumsan	35 21.1	128 36.6	CG	L(2)	R, U	32-54 (14)	1981
Jinjeon	35 09.7	128 22.1	CG	L(1)	F, N	25-28	1992
Sodaab	35 24.0	128 34.8	CG	L(1)	F, N	34-37	1985
Kaacho	35 24.2	128 35.8	CG	L(1)	F, N	26	1987
Deungeok	35 33.3	129 05.4	CG	L(1)	F, N	30	1988
Woolsan	35 27.9	129 10.5	CG	L(1)	F, N	26-29	1989
Handoo	35 05.8	128 22.2	S	L(1)	F, N	26-29	1990
Kyungbook							
Baekahm	36 35.7	129 20.5	CG	L(1)	R, U	30-53 (33)	1981
Deokgoo	37 04.5	129 16.9	M	L(1)	R, U	38.5 (3)	1983
Kyungsan	35 51.4	128 49.3	MS	L(1)	R, U	27-29	1987
Moonjangdae	35 00.7	127 49.6	JG	L(1)	F, U	32.0	1985
Cheongdo	35 41.9	128 43.1	V	L(1)	F, U	31 - 32	1985
Kyungju	35 46.4	129 18.0	CG	L(1)	F, U	27	1987
Bohmoon	35 51.0	129 16.1	MS	L(1)	F, N	25-35	1991
Pohang	36 01.6	129 21.7	MS	L(1)	F, U	37-42	1988
Yeongilman	36 57.0	129 22.8	MS	L(1)	F, N	28-30	1989
Dosahn	36 44.9	128 49.4	JG	L(1)	F, N	25.3	1991
Seokjeong	35 45.9	128 45.9	V	L(1)	F, N	26.9	1991
Hwanam	36 05.2	128 52.1	MS	L(1)	F, N	30.4	1991
Oheosa	35 57.5	129 23.4	MS	L(1)	P, N	27.8	1993
Jeonnam							
Hwasoon	35 09.9	127 05.4	MS	L(1)	F, U	34	1983
Dogok	35 01.0	126 54.0	MS	L(1)	F, N	27.5	1988
Jielisan	35 18.6	127 28.8	M	L(1)	F, N	28	1987
Weolchoolsan	34 48.6	126 39.2	CG	L(1)	P, N	28	1993
Moodeungsan	35 08.7	126 56.9	V/CG	L(1)	F, U	26.7	1989
Woonlim	35 07.8	126 57.9	V/CG	L(1)	F, N	26.5	1990
Jeonbook							
Kooahm	35 27.7	126 53.2	V	L(1)	F, N	26.2	1989
Byunsan	35 41.1	126 33.7	V	L(1)	F, U	25-26	1990
Seokjeong	35 25.3	126 44.0	V	L(1)	F, N	25-30	1990
Seongsoo	35 43.5	127 17.4	MS	L(1)	F, N	25.8	1990
Jooklim	35 43.9	127 13.9	MS	L(1)	F, N	25.8	1990
Hwasiem	35 50.2	127 16.7	MS	L(1)	F, N	28.2	1992
Daedoonsan	36 06.9	127 20.3	MS	L(1)	F, N	25.2	1992
Wangkoong	35 55.3	127 03.9	MS	L(1)	F, N	25-26	1992
Sangsong	35 27.9	126 53.3	V	L(1)	P, N	25-30	1993
Choongnam							
Onyang	36 46.9	127 00.2	JG	L(1)	R, U	32-57 (82)	1981
Doko	36 45.5	126 53.3	JG	L(1)	R, U	28-29 (26)	1981
Ahsan	36 51.1	126 59.0	M	L(1)	F, N	26.8	1989

TABLE 1 - (Continued)

Locality	Location		Reservoir		Status[3]	Reservoir Temp. ℃ and (No. Systems)	Year[4] Approved
	Latitude (N)	Longitude (E)	Rock[1]	Water[2]			
Deuksan	36 41.1	126 39.7	JG	L(1)	R, U	36-45 (11)	1981
Soodeok	36 38.4	126 39.0	CG	L(1)	F, N	27.9	1992
Donghaksa	36 21.5	127 15.2	JG	L(1)	F, N	30	1987
Mahgok	36 32.3	127 00.8	M	L(1)	P, N	25.8	1993
Hongju	36 35.8	126 39.9	CG	L(1)	P, N	25-34	1993
Cheonan	36 45.1	127 13.3	JG	L(1)	P, N	26-27	1994
Yuseong	36 20.8	127 20.0	JG	L(1)	R, U	29-56 (44)	1981
Choongbook							
Sooahnbo	36 50.8	127 27.1	M	L(1)	R, U	43-51 (5)	1981
Neungahm	37 05.2	127 47.9	M	L(1)	F, U	27 .	1987
Choongon	37 05.9	127 47.2	JG	L(1)	F, N	27	1987
Donsan	37 05.6	127 47.6	JG	L(1)	F, N	31.8	1992
Choongju	36 59.4	127 57.2	JG	L(1)	F, N	25.3	1990
Weolahk	36 52.6	128 04.9	JG	L(1)	P, N	25-30	1993
Kangweon							
Osaek	38 04.6	128 25.6	JG	L(1)	R, U	35	1981
Cheoksan	38 11.2	128 32.5	JG	L(1)	R, U	44	1981
Seolahk	37 09.5	128 33.9	JG	L(1)	P, N	28	1993
Weonahm	38 12.5	128 30.5	CG	L(1)	P, N	25-42	1993
Hongcheon	37 42.0	127 50.5	M	L(1)	F, N	25.1	1991
Yonghwa	38 03.4	127 43.4	S	L(1)	F, N	27.6	1992
Yeongweol	37 12.4	128 31.1	M	L(1)	F, N	25.7	1992
Kyunggi							
Icheon	37 16.4	127 27.3	JG	L(1)	R, U	31 (6)	1981
Yahkahm	37 37.7	126 33.2	S	L(1)	F, N	28.6	1989
Hwaseong	37 08.4	126 52.4	M	L(1)	F, N	26.6	1992
Weolmoon	37 06.7	126 52.6	M	L(1)	P, N	25.8	1993
Deokjeong	37 41.2	126 27.2	M	L(1)	F, N	27-31	1992
Sinbook	37 57.8	127 06.9	M	L(1)	F, N	25.9	1992
Ildong	37 58.8	127 20.5	JG	L(1)	P, N	31-35	1993
Yongmoon	37 28.7	127 34.4	M	L(1)	P, N	26	1993

TABLE 2. INFORMATION ABOUT GEOTHERMAL LOCALITIES IN NORTH KOREA

Locality	Location		Reservoir		Status[3]	Reservoir Temp. ℃ and (No. Systems)	Year[4] Approved
	Latitude (N)	Longitude (E)	Rock[1]	Water[2]			
Yangkang							
Bocheon	41 32.8	128 23.1	V	L(1)	U	40	1982
Hahmbook							
Panjang	42 01.5	129 57.1	TG	L(1)	U	35	1982
Yongcheon	41 45.7	129 35.9	M	L(1)	U	39	1982
Onpo	41 39.8	129 30.3	M	L(1)	U	57	1982
Jueul	41 35.7	129 32.6	M		U		1982
Bosang	41 32.6	129 21.6	CG		U		1982
Seongcheon	41 33.3	129 26.5	CG		U		1982
Kwanmo	41 33.1	129 28.8	CG	L(1)	U	51	1982
Sienwoong	41 21.3	129 28.8	V		U		1982
Sampo	41 16.5	129 45.0	M		U		1982
Hwangjin	41 06.7	129 41.3	M	L(1)	U	52	1982
Eunsoo-pyung	41 03.0	129 21.9	V		U		1982
Sihbil	40 59.6	129 16.0	S		U		1982
Secheon	40 51.9	129 08.6	M	L(1)	U	70.1	1982
Songheung	40 45.7	129 06.3	M	L(1)	U	46	1982
Pyungbook							
Sakju	40 19.6	125 02.9	M	L(1)	U	59	1982
Woonsan	40 06.3	125 54.1	TG	L(1)	U	54.4	1982
Sahcheon	39 58.9	125 53.5	JG	L(1)	U	39	1982
Jakang							
Weonheung	40 12.1	126 29.5	M	L(1)	U	45	1982
Sohmoo	40 12.3	126 43.6	M	L(1)	U	51	1982

TABLE 2 - (Continued)

Locality	Location		Reservoir		Status[3]	Reservoir Temp. ℃ and (No. Systems)	Year[4] Approved
	Latitude (N)	Longitude (E)	Rock[1]	Water[2]			
Pyungnam							
Onyang	39 59.6	126 46.3	CG	L(1)	U	60	1982
Yongkang	38 51.8	125 13.8	CG	L(3)	U	55	1982
Seongcheon	39 20.1	126 03.9	JG	L(1)	U	45.5	1982
Yangdeok	39 15.2	126 40.0	CG	L(1)	U	49	1982
Seoktan	39 12.6	126 50.1	CG	L(1)	U	78	1982
Hahmnam							
Inheung	39 29.0	127 22.4	M	L(2)	U	36.5	1982
Hwangnam							
Chojeong	38 38.9	125 29.4	M	L(2)	U		1982
Anahk	38 35.0	125 24.1	CG		U		1982
Dahlcheon	38 24.2	125 14.7	CG	L(1)	U	45.5	1982
Samcheon	38 22.2	125 20.4	CG	L(1)	U	54	1982
Songhwa	38 19.9	125 09.0	CG	L(1)	U	46.7	1982
Sihncheon	38 21.2	125 31.2	M	L(1)	U	54.7	1982
Ihmok	37 59.3	125 35.2	M		U		1982
Pyungsan	38 07.8	126 12.8	JG	L(1)	U	54	1982
Baecheon	37 59.3	126 18.5	M	L(1)	U	73.8	1982
Kangweon							
Lohtan	38 53.1	127 03.8	JG	L(1)	U	52	1982
Kalsan	38 48.3	127 02.5	JG	L(1)	U	45	1982
Oekeumkang	38 41.4	128 10.1	CG	L(1)	U	43.4	1982

TABLE 3 - WELLS DRILLED FOR THE UTILZATION OF GEOTHERMAL RESOURCES IN SOUTH KOREA

* Type or purpose of well and manner of prodution
(Use one symbol from column(1) and one from column(2))
(1) T = Thermal gradient or other scientific purpose
E = Exploration
P = Production
I = Injection
C= Combined electrical and direct use
(2) A = Artesian
P = Pumped
F = Flashing

Locality	Year Drilled	Type of Well (1)	Type of Well (2)	Total Depth (meter)	Maximum Temp.(℃)	Thermal Gradient (℃/ km)	Flow Rate (kg/ s)
Pusan							
Eumkoong	1990	P	P	602	28.4		
Donglae-1, 6	1992	P	P	204	38.4		
Kyungnam							
Eunhyun	1992	E	P	684	32.9	25.0	8.1
Nahmchang-1, 2	1988	E	P	464	26.6		
Taehwa-1, 2	1990	E	P	592	30.0		
Eunyang-1, 3	1987	E	P	624	30.0	26.0	2.9
Euichang-1, 2	1990	E	P	454	28.2	25.3	-
Dongsan	1991	E	P	454	34.2		
Koseung-1, 11	1989	E	P	424	24.7	21.0	5.9
Sahcheon	1988	E	P	628	31.3	24.9	3.5
Hadong	1991	E	P	738	28.4		
Keochang-1, 2	1989	E	P	502	25.8	25.0	-
Kyungbook							
Taegu	1991	E	P	698	30.1		
Kyungsan	1990	P	P	602	28.7	23.5	-
Kyungju-1, 2	1989	P	P	594	27.5	23.7	-
Okmyung-1, 6	1987	E	A	256	22.3	22.6	11.6
Pohang-1, 6	1988	P	P	526	42.0	29.8	3.5
Youngil-1, 4	1989	P	P	410	28.0	26.7	8.1

TABLE 3 - (Continued)

Locality	Year Drilled	Type of Well (1)	Type of Well (2)	Total Depth (meter)	Maximum Temp.(℃)	Thermal Gradient (℃/ km)	Flow Rate (kg/ s)
Sihnkwang-1, 4	1992	E	A	160	32.4		
Youngcheon-1, 2	1989	E	P	536	29.3		
Hwanam	1990	E	P	652	31.9	25.0	1.6
Keumho-1, 4	1992	E	P	604	33.7		
Andong-1, 2	1989	E	P	534	26.1	23.5	3.4
Euiseong-1, 4	1992	E	P	816	32.6		
Jeonam							
Youngahm-1, 3	1990	E	P	650	28.1		
Yeosoo	1988	E	P	620	30.0	25.4	-
Koorie	1987	E	P	580	28.3	24.3	-
Dogok-1, 10	1987	E	A	60	16.6	22.7	3.2
Kwangju-1, 4	1988	P	P	688	27.6	22.0	2.9
Cheju							
Bookcheju-1, 2	1990	E	P	670	37.8		
Sehwa-1, 5	1992	E	P	712	27.3		
Jeonbook							
Wanju-1, 5	1990	E	P	658	31.8	26.0	3.3
Woonju	1990	E	P	568	25.1		
Keumdang-1, 2	1989	E	P	698	28.6		
Iksan	1992	E	P	680	29.8		
Jinahn	1990	E	P	696	29.2	21.5	2.7
Soonchang-1, 2	1989	E	P	655	28.4	22.0	-
Kochang-1, 2	1989	E	P	672	29.4	24.0	-
Booahn-1, 3	1989	P	P	604	28.1	25.0	-
Jangsoo	1989	T	-	308	19.8		
Nahmweon	1989	T	-	350	21.4		
Choongnam							
Sahgok	1992	E	P	804	23.7		
Cheonan-1, 2	1991	E	P	540	25.3		
Onyang-1, 6	1987	E	P	250	25.2	30.0	7.5
Doko-1, 7	1989	P	P	298	27.3	25.0	6.9
Yuseong-1, 4	1990	P	P	464	31.1		
Songseok	1989	T	P	600	26.6	20.0	-
Hongseong-1, 2	1991	E	P	580	30.2		
Deoksan-1, 15	1987	P	A	128	31.8	30.0	5.8
Sahbkyo	1991	E	P	736	34.1		
Kyuahm-1, 6	1992	E	P	670	29.7		
Kangrae	1992	T	P	500	30.5		
Choongbook							
Cheongweon-1, 2	1989	E	P	634	26.5		
Choongju-1, 4	1988	P	P	612	25.6	21.1	3.1
Joongweon-1, 3	1989	E	P	678	33.5	20.0	-
Songgae	1992	E	P	250	35.6		
Keoisahn	1990	E	P	570	27.5	20.7	-
Kangweon							
Hongcheon-1, 2	1989	E	P	656	28.4	22.4	-
Youngweol	1991	E	P	838	31.2		
Sokcho	1991	E	P	498	31.1	30.0	5.2
Koseong-1, 7	1991	E	P	364	34.5		
Domoon-1, 2	1992	E	P	726	37.8		
Kyunggi							
Ahnseong	1992	E	P	598	26.6		
Yangpyung	1992	E	P	604	27.9	23.2	-
Hwaseong-1, 5	1989	E	P	690	28.7	23.2	3.1
Kimpo	1987	E	P	688	27.1	23.0	1.4
Ahnsan	1990	E	P	654	27.2	20.0	0.9

TABLE 3 - (Continued)

Locality	Year Drilled	Type of Well (1)	(2)	Total Depth (meter)	Maximum Temp.(℃)	Thermal Gradient (℃/ km)	Flow Rate (kg/ s)
Booleum	1990	E	P	644	27.9	25.5	3.2
Pocheon	1990	P	P	592	29.1	26.0	6.4
Ildong-1, 11	1990	E	P	494	34.8	30.0	9.8
Hwacheon-1, 2	1990	E	P	688	31.1		
Seoul							
Myonmok	1991	E	P	580	29.2		
Sanggae	1989	E	P	322	21.9	25.8	-
Onsoo	1989	E	P	292	19.8	23.2	-

CONCLUSION

The geothermal potential is large for the low temperature energy in Korea. Based on the geothermal data of Tables 1, 2 and 3, listed in this paper, drilling projects were conducted for the business and regional development. The limited space and district heating using geothermal energy greater than 50℃ can be estimated to have a potential around 10 sites. Greenhouses can utilize thermal temperatures as low as 24℃. There are many geothermal resources, but limited information is available about them. Fish farming is one of the fast growing application of thermal water. Only a very small part of that is geothermal and it is well known that growth rate is enhanced with geothermal aquaculture where water temperature is maintained relatively constant.

The private programs of the late 1980's were encouraged. For the all geothermal projects, commercial exploitation is now a reality and the drilled wells of geothermal exploration are still being utilized. Because of the control of government and the economic conditions, the competitiveness of geothrmal energy development has declined in 1990s, and the cost of geothermal exploration and confirmation is constraining accelerated development. Table 3 significantly shows more drilled wells. There is an enormous potential of using low temperature energy for baths, greenhouses and fish farming. However, there is a need for the governmental support and control of drilling projects for the exploitation of new geothermal energy and country update of thermal information.

REFERENCES

Baekwa Jeonsuh, 1982. "Hot Springs in North Korea," Science & Encyclopedia Pub. Co. Vol. 1-6, pp. 236-884.

Bookhahn Chonglahm, 1983. "Geothermal Development of North Korea," Res. Inst. of North Korea, pp 997-999.

Department of Home Affairs, Republic of Korea, 1983. "Hot Springs in the book Oncheonji," pp. 148-243.

Department of Home Affairs, Republic of Korea, 1994. "Chart of the Approval on the Hot Spring Area in South Korea," pp. 1-2.

Han, U., 1979. "A Preliminary Evaluation of Geothermal Potential of Korea with Emphasis on Geothermometer," J. Geol. Soc. of Korea (JGSK), Vol. 15, pp. 259-268.

Han, U., 1984. "Heat Flow Profile in the Vicinity of Korean Peninsula," JGSK, Vol. 20, pp. 379.

Han, U., 1985. "On the Regional Heat Flow around Korea and Reduced Heat Flow," JGSK, Vol. 21, pp.74-78.

Han, U., 1986. "Geophysical and Geochemical Study on the Geothermal Potential in the Choongboo Area (I)," Choongnam, Report.

Han, U., 1987. "Geophysical and Geochemical Study on the Geothermal Potential in the Choongboo Area (II)," Choongnam, Report.

Han, U., 1988a. "Geothermal Potential Evaluation around the Yuseong Hot Spring Area," Taejon City, Report.

Han, U., 1988b. "Geothermal Potential Evaluation in the Jeonbook Province," Jeonbook, Report.

Han, U., 1990. "A Geothermal Aspect on the Thermotectonic Structure of Korea," IGCP, Vol. 224, Ulan Ude, USSR.

Han, U., 1992. "Heat Flow and Physiographic Boundary of Korean Peninsula," Russia Geogr. Soc., Khabarovsk, Russia.

Han, U., 1993. "Geothermal Survey on the Vicinity of Yuseong Hot Spring," Taejon City, Report.

Han, U., 1994. "Heat Flow Provinces in the Korean Peninsula and Its Vicinity," IASPEI 94, Wellington, New Zealand.

Han, U. and Chapman, D. S., 1981. "Heat Flow in South Korea," EOS Trans., San Francisco, USA.

Han, U., Jung, B. I. and Lee, K. H., 1981. "Geological and Geophysical Survey on the Thermal State of Deuksan Hot Spring," Nat. Sci. Int., S.N.U.

Han, U. and Koo, M. H., 1991. "A Study on the Thermal State of Kwangju Fault and Its Vicinity," KOSEF, Report.

Han, U. and Koo, M. H., 1992. "Geophysical and Geochemical Survey on the Geothermal Exploration in the Booahn Area," Booahnkun, Report.

Han, U., Kown, Y. S. and Lee, H. H., 1979. "Heat Flow and Physiographic Boundary around Korea," J. KMA, Vol. 19, pp. 301-310.

Koo, M. H., Han, U. and Kwon, B. D., 1993. "A Study on the Thermal State of Kongju Basin and Its Vicinity," JKES, Vol. 14, pp. 58-66.

Lee, K. K., Han, U. and Lee, K. H., 1986. "A Study on the Thermal Structure of the Kyungsang Basin," JGSK, Vol. 22, pp. 371-379.