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Recent Gold Exploration in Japan

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ABSTRACT : Domestic metal mines have contributed to the national industrialization of Japan for over a century through their stable supply of raw materials. However, due to the changes which have taken place in the industries structure, mining industry has been shifted to downstream industries. At present, only three major mines are in production. In recent times, changing economic conditions have made it increasingly difficult to develop new base metal mines. Subsequently, the deposit type targeted has shifted from base metals to epithermal associated gold deposits which, if of sufficient grade and tonnage, can be economical. Accompanying the dramatic rise in the price of gold during the late 1970's, has been an increase in the geological information and our understanding of epithermal gold deposits around the Pacific rim region. In particular, the common acceptance of the plate tectonic theory and the correlation's between modern geothermal systems and fossil epithermal systems were most important developments. In 1988, the Mining Council authorized the domestic exploration of 19 districts, targeting epithermal gold mineralization. Since 1989 the Metal Mining Agency of Japan, semi-government organization, has been conducted gold exploration in such area. With new genetic concepts and new technologies,promising gold mineralization has been discovered. Two such areas which are at an advanced stage of exploration are Seta, in northern Hokkaido, and Noya, in central Kyushu.

INTRODUCTION

Since the late 1970s, discoveries of huge epithermal gold deposits have been reported in the Pacific rim region such as McLaughlin, Goldstrike (USA), Yanacocha (Peru), El Indio (Chile), Hishikari (Japan), Gunung Pongor, Kelian (Indonesia), Porgera, Ladolam (PNG) etc. Exploration for epithermal gold deposits continues with regions such as Bolivia, Argentina, Peru, Chile, Central America, Indonesia and the Philippines receiving increasing attention. This boom in the exploration for gold was brought about by the potential high earning rate of gold mining. The price of gold has jumped to over ten times higher than previous prices following the freeing of the gold price on August 15 of 1971. Not only junior but also major mining companies started investing in gold exploration rather than the concentrated exploration efforts directed at porphyry copper. Gold mining was called the last game in the town (Green, 1987). Investment today in gold exploration by major mining companies occupies 40% of total exploration investment in non-ferrous metals deposits worldwide (Metal Economics Group, 1995).

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Accompanying this boom in gold exploration was the realization that epithermal gold deposits are the fossil equivalents of modern day active geothermal systems. As a result, numerous characteristics incorporating the research and exploration results of both these environments have been documented and have proven extremely valuable in the development of criteria useful in mineral exploration. This has also contributed to the development and implementation of more specific exploration strategies and methodologies.

The discovery of the Hishikari gold deposit in 1981 by the Metal Mining Agency of Japan triggered a gold exploration rush in Japan which included activities by foreign mining companies. Japan is thought to still have potential for the discovery of new gold deposits as it is a region of magmatic/volcanic activity located at a convergent plate margin, the same tectonic setting which characterize the recently discovered huge gold deposits. However, in the 1990s, mining companies became reluctant to invest further in gold exploration because of the difficulty in finding gold ore deposits and maintaining profitable mines. Accordingly, they changed their corporate strategies, diversifying their management to downstream industries. The dull metal market in Japan has been in part caused by the high yen evaluation and increased operation costs due to high wage and environmental costs. Currently, organizations which are actively implementing new exploration programs for base and precious metals in Japan is restricted to the Metal Mining Agency of Japan.

In this paper, I would like to introduce the general process of gold exploration from the selection of a target area to the detailed exploration stage which the MMAJ has taken. In doing so I will discuss two examples which represent promising projects; Seta in northern Hokkaido, and Noya in central Kyushu.

BACK GROUND OF GOLD EXPLORATION IN JAPAN

Japan was once called "the Golden Country of Zipangu" by Marco Polo in the 13th century when it was realized that Japan was a country abundant in various mineral resources. Japan was one of the main mineral producing countries in the world. In 1910, 82% of copper produced domestically was exported. The mining industry was in full flourish as a raw material supplier for modern industries until the later half of the 1960s. However, the domestic metal mines lost their international competitiveness and have been forced to close due to high production costs and low metal prices caused by the high yen evaluation. The number of mines and their employees have drastically decreased from 821 and 67,860 in 1950 to 22 and 1, 942 in 1990, respectively. Today, there are only three metal mines which employee over 100 staff; Toyoha (epithermal Zn, Pb, Cu), Kamioka (Zn, Pb skarn) and Hishikari (epithermal Au, Ag) mines. On the contrary, in accordance with economic growth, demand for non-ferrous metals became so intense that domestic mining companies strengthened their smelting facilities, in effect becoming "custom smelter". Although Japan is one of the biggest producers of nonferrous metals in the world, producing 10.3% of copper, 5.7% of lead and 9.8% of zinc in 1993, in the same year, Japanese mines could only supply 0.3%, 10.7% and 19.0% of total domestic demand for Cu, Pb, and Zn, respectively. Zinc and lead smelting companies began losing their international competitiveness and in 1994, mining companies started restructuring their lead and zinc smelters. With such drastic changes taking place in the mining industry in Japan, the Metal Mining Agency of Japan has been undertaking mineral exploration to encourage mining activity in Japan. However, to develop a base metal mine from grass roots exploration has become quite difficult in Japan. Only gold or gold-bearing deposits are now considered to have economical value under the current economic conditions.

In 1988, the Mining Council, an advisory organ of the Minister of International Trade and Industry of Japan, advised the MMAJ to shift domestic mineral exploration from base metal to gold or gold bearing base metal deposits.

SELECTION OF TARGET DISTRICT FOR REGIONAL EXPLORATION

The Japanese Island is located at the western extremity of the Eurasia plate and is composed of an amalgamation of ancient subduction-accretionary complexes, remnant arc complexes and micro continental fragments of pre-Miocene age (Isozaki *et al.*, 1990). With the opening of the Japan Sea approximately 15 Ma BP, the Japanese islands were separated from the Eurasian continent and occupied their present position as an island arc with westward subduction of the Pacific and Philippine plate. All of the known epithermal gold deposits have a similar distribution to Neogene to Quaternary island arc volcanics as shown in Fig. 1 and are though to be generated by volcano-geothermal activity at that time (see Fig. 3). The tectonic setting of epithermal gold deposit in the Japanese islands closely resembles that of other epithermal gold deposits discovered around

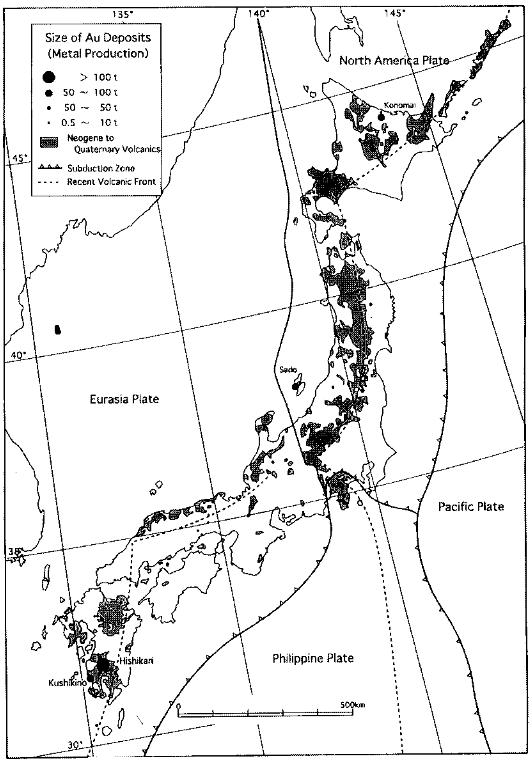

Fig. 1. Distribution of Neogene to Quaternary volcanics and epithermal gold deposits in Japan.

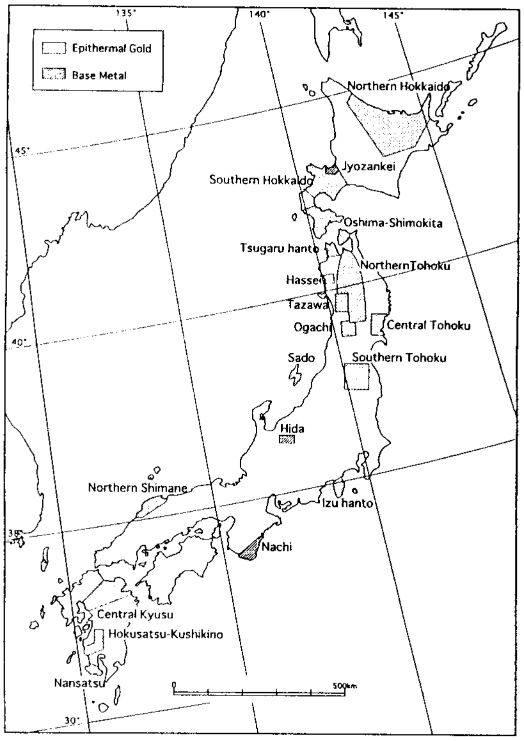

Fig. 2. Regional geological survey areas for precious- and base-metal deposits which were selected and authorized by the Mining Council in 1988.

the Pacific rim. That is, they occur in a magmatic arc located at a convergent plate margin. In 1988, 19 target districts (including those previously chosen e.g. Izu, Sado, Hokusatsu-Kushikino, Nansatsu) including northern Hokkaido, southern Hokkaido, Oshima-Shimokita, northern Tohoku, central Tohoku, southern Tohoku and central Kyushu, shown in Fig. 2, were chosen based on several criteria including the presence of known gold deposits, paleo or present geothermal activity, and subaerial volcanics of Miocene to Quaternary age.

Since the first production of gold recorded in Japan in 749 from the Tohoku district, around 1000 t of gold has been produced from over 800 gold mines up until the operation of the Hishikari gold deposit in 1985. Almost all deposits were discovered by identifying outcropping gold bearing quartz veins or float from enthusiastic exploration by "Yamashi", the Japanese word for old time explorers. As a consequence of the thorough surface exploration by the Yamashi, present day exploration programs must target blind or concealed deposits.

EXPLORATION PROCEDURES

In order to implement exploration programs more efficiently, it is important to establish and rigorously follow exploration strategies. A part of the exploration strategy must identify the exploration methods most suited to the targeted deposit type and how to evaluate the results effectively. In terms of epithermal gold deposits, many factors may vary by region and therefore it is extremely important to gather data previously acquired from or close by the targeted area and take into consideration when developing a working model to be used during exploration. Information concerning epithermal gold deposits in Japan has continually been accumulated since the implementation of exploration programs directed at this style of mineralization. Such an approach resulted in the discovery of the Hishikari gold deposit (Metal Mining Agency of Japan, Sumitomo Metal Mining Co., Ltd., 1987), but in addition, a wealth of new geological and mineralogical information has been obtained during the development of the deposit (Abe *et al.*, 1986; Izawa *et al.*, 1990; MITI, 1990; Naito *et al.*, 1993; Kawasaki *et al.*, 1986; Shiokawa *et al.*, 1992; Ibaraki, Suzuki, 1990). In addition, case histories of the same type of gold exploration throughout the world have contributed to our recent domestic gold exploration programs.

Various genetic concepts for the low sulfidation type gold deposit have been proposed by many researchers and exploration geologists such as Sillitoe (1993), Sillitoe (1994), Hedenquist, Lawenstern (1995), and White, Hedenquist (1995). A conventional schematic genetic concept for exploration of low sulfidation type gold deposits is illustrated in Fig. 3. A brief summary of the genesis of this type of deposit is now presented based on the work of Berger, Eimon (1983), Hedenquist, Lowenstern (1995), White, Hedenquist (1995).

Fluids dominated by meteoric water with some magmatic component ascend from deeper levels heated by a magmatic intrusion. The fluids equilibrate with surrounding rocks and become neutralized or reduced. During the course of ascent, the fluid may boil and/or mix with cooler meteoric water at shallower levels, gold which is transported as bisulfide complexes will precipitate contemporaneously with silica from the fluid to form gold bearing quartz veins. When released H_2S gas is reacts with ground water above the vandoze zone, acid-sulfate waters from oxidation of H_2S will be generated. These fluids leach the country rock to form acid leached rock, sometimes refereed to as "sponge" rock. Outflow of hydrothermal solutions at the surface may result in hot spring precipitates such

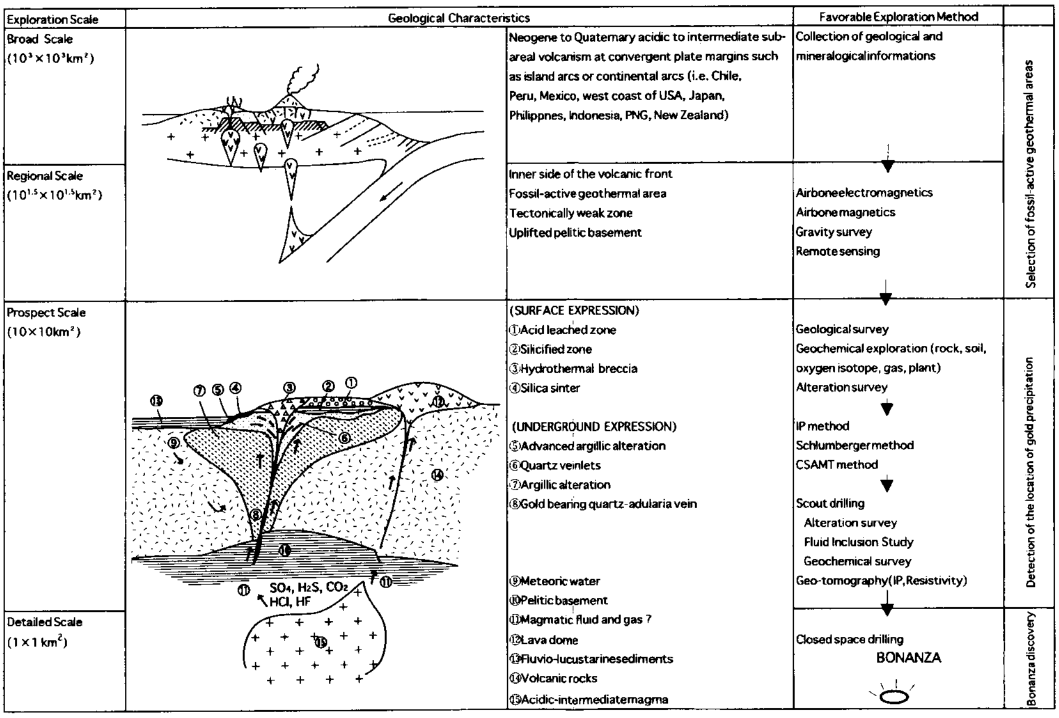

Fig. 3. Favorable exploration methodologies of epithermal gold deposit in Japan.

as siliceous sinter or gases released through fumeroles may precipitate native sulfur. Rising silica saturated fluids may mix with meteoric water at the watertable, resulting in a massive silicification zone. At deeper levels, advanced argillic or argillic alteration of the country rock may take place by reaction with descending acid-sulfate waters (Sillitoe, 1993). Hydrothermal breccias may also be present and may have formed through a build up of pressure due to the sealing of pore space by silica or clay. In some cases they are visible at the surface and may be valuable indicators of the subsurface geology and mineralization.

Broad scale exploration

Cenozoic to Quaternary terrestrial volcanic terrain associated with plate subduction, magma arc, are worthy of consideration at the first step. Old mining records, distribution of hot springs and data of geothermal exploration are useful to select the target. This stage of exploration, we had better call it just study, will be done at the desk in Japan such that detailed geological survey has already been carried out . As shown in previously, 19 district for regional exploration were chosen in this stage.

Regional scale exploration

In order to unravel the subsurface geology, various techniques are are effective such as lineament analysis of satellite imagery, gravity surveys and airborne magnetics. Airborne electromagnetics is useful to delineate regional and shallow hydrothermally altered zones. Furthermore, information concerning old mines, hot springs and hydrothermal clay deposits are also important factors in choosing promising areas. In the case of the discovery of the Hishikari deposit, duality of small scale gravity highs and low resistivity anomalies detected by airborne electromagnetics were clues used to delineate a promising target area (Metal Mining Agency of Japan, Sumitomo Metal Mining Co., Ltd., 1987).

Prospect scale exploration

At this stage of exploration, the genetic concept described previously is most important in order to choose favorable exploration procedures, and to analyze and asses the survey results of various methods. Exploration at this stage begins when sufficient evidence of hydrothermal activity exists which is thought to be related to epithermal gold mineralization. It must be stressed that it is extremely important to judge the present surface features in order to gain an idea of the degree of erosion and whether the present surface represents, for example, the potential bonanza level or paleosurface. This is important in interpreting various data sets and also because if the bonanza level is exposed, there is no need to explore very deep in the system. In Japan, almost all outcrops of gold bearing quartz veins were already examined by the old time explorers. On the contrary, if the surface expressions of geothermal activity such as silica sinter, hydrothermal breccia, acid leached rock, and advanced argillic alteration are preserved, mineralization will be expected at deeper levels. It is generally known that gold precipitates between approximately 180 and 280 from hydrothermal solution. Not only fluid inclusion homogenization temperature, but also alteration zoning is a useful tool to estimate paleothermal variation. By studying active geothermal systems, a direct correlation between alteration mineralogy and temperature is well known (Silberman, Bergar, 1985; Reyes, 1990). At the Hishikari deposit, four alteration zones from proximal to distal, cristobalite-smectite, quartz-smectite, quartz-interstratified chlorite (sericite)/ smectite and quartz-chlorite (sericite) were identified. Gold bearing quartz veins are confined to the quartz-chlorite (sericite) zone (Ibaraki, Suzuki, 1990). Sometimes acid alteration characterized by kaolinite and alunite are superimposed on neutral-pH alteration. It is important to distinguish acid alteration caused by steam heated acid sulfate waters from advanced argillic alteration related to fluids derived directly from a high sulfidation system (White, Hedenquist, 1995). As, Sb, Hg, Tl and Au tend to be concentrate in the upper parts of geothermal systems and decrease with increasing depth (Berger, Eimon, 1983; Silberman, Berger, 1985). Rock and soil geochemical surveys using As, Sb, Hg, Tl and Au are also common procedures to delineate the domain of gold mineralization. Stream sediment geochemical are seldom used because outcropping gold mineralization were already explored and concealed gold deposits are now targeted. Geo-gas, Hg Radon and CO_2-gas methods have been applied to identify the fissures where gas carrying metals have emanated. However, although apparently successful in some cases, their effectiveness has not still yet to be clarified. Oxygen isotopic mapping has been proposed as a new exploration tool. Naito *et al.* (1992) clarified that the oxygen isotopic ratio (δO^{18} values) of hydrothermally altered country rocks decrease from +16‰ in the low temperature alteration zones to +2‰ in the most intensely altered zone due to isotopic exchange of wall rocks and hydrothermal solutions in the Hishikari deposit.

Together with geological and geochemical surveys, geophysical surveys such as Schlumberger and/or CSAMT are applied in order to unravel the subsurface geology in terms of resistivity. Broad silicified zones and quartz veins are indicated by zones of higher resistivity, whereas argillicaly altered zones represent lower resistivity. The IP method is also useful to delineate areas of pyritization in the argillically altered zone. As a rule, scout drilling is carried out to check the results obtained by previous exploration, and confirm genetic concept considered in advance. By using drill cores, geochemical and alteration studies are usually implemented, similar to that as surface exploration, in order to grasp the three dimensional variation.

Detailed exploration

During detailed exploration, when promising mineralization has already been discovered, closed space grid drilling from the surface and/or underground are executed. Resistivity image profiling and tomography implementing the downhole method have been developed by MMAJ to infer the geology between drill holes.

CASE STUDY OF EXPLORATION OF THE SETA AREA, NORTHERN HOKKAIDO DISTRICT

The northern Hokkaido district is located in the northeastern part of Hokkaido, where the Kuril arc and Northeast Japan arc meet. Typical arc-type volcanism has characterized this area since 6 Ma and atypical arc type volcanism from 14 to 9 Ma (Goto *et al.*, 1995; Kokubu *et al.*, 1995). Neogene to Quaternary volcanics unconformably overly a pre-Neogene accretionary prism composed of flysh sediments and greenstone melange (Fig. 5) Active geothermal areas and hot springs are located along the volcanic arc along with Quaternary volcanoes. More than 40 old gold mines and mineral showings are scattered in this district. Total gold production in this district has been estimated around 88.65t, including the Konomai mine which produced 73.2t of gold.

The regional geological survey of the 15,000 km^2 area began in 1989 with airborne electromagnetic and geological surveys in the central part of the district which was initially considered to be the most promising target. After the preliminary exploration

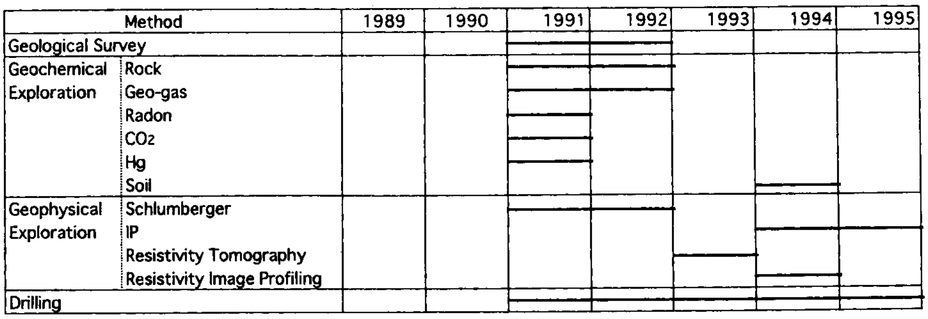

Fig. 4. Distribution of the selected survey area and gold deposits in the northern Hokkaido district.

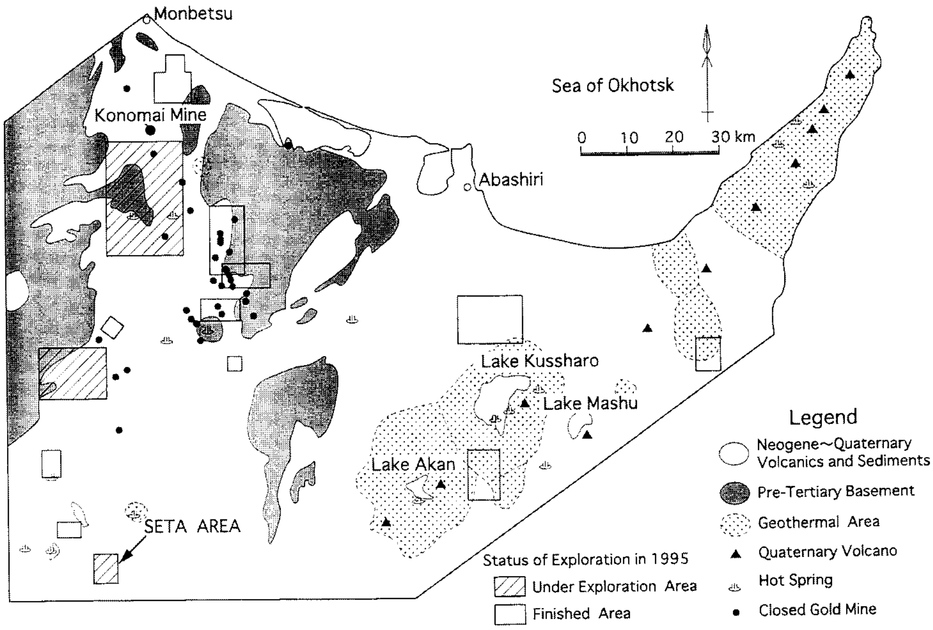

Fig. 5. Exploration methodology applied to the Seta area, the northern Hokkaido district.

(Regional Scale), several promising targets of smaller area were chosen and explored (Prospect Scale), however results were disappointing.

The Seta area is located in the southern most extremity of the selected district. A clue to the potential of this area was the discovery of gold bearing quartz veins in 1991 during exploration by the Geological Survey of Hokkaido (Yahata *et al.*, 1992). In the same area, a mercury deposit was first exploited at the surface in the 1940s, then several kaolin deposits were exploited underground until the 1960s. Today, zeolite is now mined in the same area. Unfortunately, no one noticed the existence of gold mineralization. The Metal Mining Agency of Japan has therefore implemented an exploration program for epithermal gold since the discovery in 1991. A flow diagram of the surveys carried out to date is shown in Fig. 4.

The stratigraphy in this area is characterized by lower pyroxene andesite of middle Miocene age, intercalated with intermediate to acidic lava, pyroclastic rocks and fluvio-lacustrine sediments of late Miocene to Pleistocene age, overlain by pyroxene andesite lavas (MITI, 1993). Following the geological survey, the distribution of acid leaching, silicification, hydrothermal brecciation and silica sinter were confirmed in an area 3 km by 1 km along the Set river (Fig. 6). These phenomena, including the mercury, kaolin and zeolite deposits, are typical surface expressions of geothermal activity, as shown in Fig. 3. In addition, Hg, As and Au soil geochemical anomalies were also detected along the Seta River (Fig. 6). Following a Schlumbeger geophysical survey over the same area, a near surface high resistivity zone over 300 ohm-m, and a near vertical medium resistivity zone of 100-300 ohm-m, were found to coincide with the distribution of shallow silicified rock and gold bearing quartz veinlets and hydrothermal breccia, respectively (Fig. 7). High chargeability zones which were thought to represent pyritization within hydrothermal breccia were also identified along the Seta River (Fig. 6). Before the completion of the geophysical and geochemical exploration, drilling was implemented and has continued since 1992.

An elongated zone of gold bearing quartz veins is inferred to strike NW-SE. Accordingly, each drill hole was placed to intersect this zone. Seventeen holes with a total length of 9,400 m were drilled up until 1994 intersecting several gold bearing quartz veins. Drill hole 5MAHB-2 intersected an 18 metre mineralized quartz vein network zone averaging 7.94 g/t Au and 110.4 g/t Ag. As shown in Fig. 7, argillic alteration has developed above the 300 m level (asl) where a zonal arrangement from a central K-feldspar zone to a peripheral smectite zone. Alunite is frequently identified at deeper levels while the distribution of kaolinite is in the form of a funnel shape extending above the hydrothermal breccias. These features are interpreted as follows: during the course of fluids ascending along fracture zones, boiling of gold bearing hydrothermal solutions occurred at relatively shallow levels resulting in precipitation of gold and degassing of H_2S from solution. H_2S-rich volatiles condensed in the vandose zone above the water table, resulting in the generation of an acid-sulfate solution. This solution leached the country rocks. In addition, silica saturated solutions mixed with ground water at the water table resulting in silicification. Residual acid-sulfate solution also descended along the feeder of ascending solutions. Kaolinization took place during drain-back of acid-sulfate solution. Judging from the above mentioned features, we consider the deposit to be of low grade but potentially contains several tens of gold.

CASE STUDY OF EXPLORATION OF THE NOYA AREA, CENTRAL KYUSHU DISTRICT

The Central Kyushu district is located on the inner side of the present volcanic front and includes the Beppu-Shimabara graben (Matsumoto, 1984). Volcanism in the district overlies the Ryoke and Sangun metamorphic belts and is related to subduction of the Philippine plate in a northwest direction since middle Miocene time. This district is one of Japans most important geothermal areas and is famous for hot-

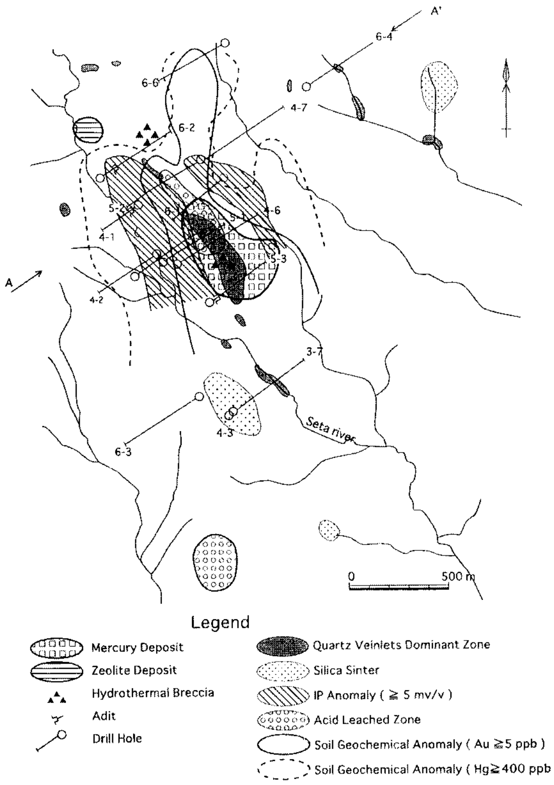

Fig. 6. Surface geological features, geochemical and geophysical anomalies of the Seta area.

springs and the Beppu and Yufuin geothermal power plants, Otake and Hachobaru. Old gold deposits including Taio (37t Au) and Bajo (13t Au) and numerous mineral showings characterize this district (Fig. 8).

Regional scale exploration of a 1500 km^2 area began in 1989 with orthodox survey methods like airborne electromagnetics and a geological survey of the central part of the district, initially considered to exhibit the most potential.

Following the regional scale exploration program, some promising target areas were chosen and explored in more detail during the early stages of the prospect scale program. The Noya area was one of the areas chosen following the recognition of a low resistivity anomalous zone delineated by airborne electromagnetics and a gold bearing quartz vein with 20 g/t Au discovered during geothermal resource drilling (Morishita, Takeno, 1989). This area is also located favorably on the edge of a depressed zone (Matsumoto *et al.*, 1993). A flow diagram of the methods adopted to date is shown in Fig. 9. In terms of the local stratigraphy, andesite lavas dated at 0.7 to 1.8 Ma, are overlain by pyroclastics and fluvio-lacustrine sediments

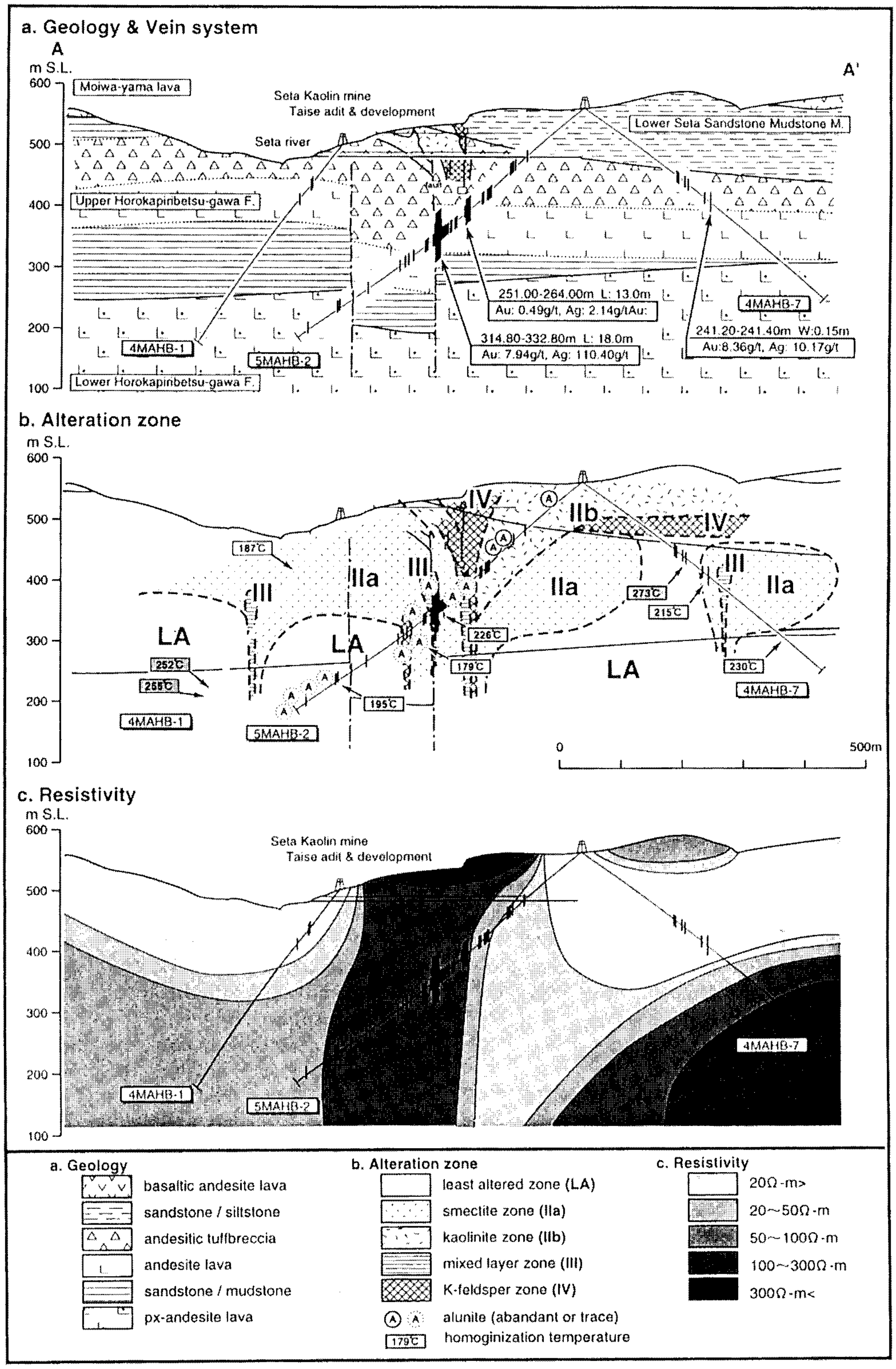

Fig. 7. Geologic cross section along the drill holes in the Seta area revised from Yamamoto (1995).

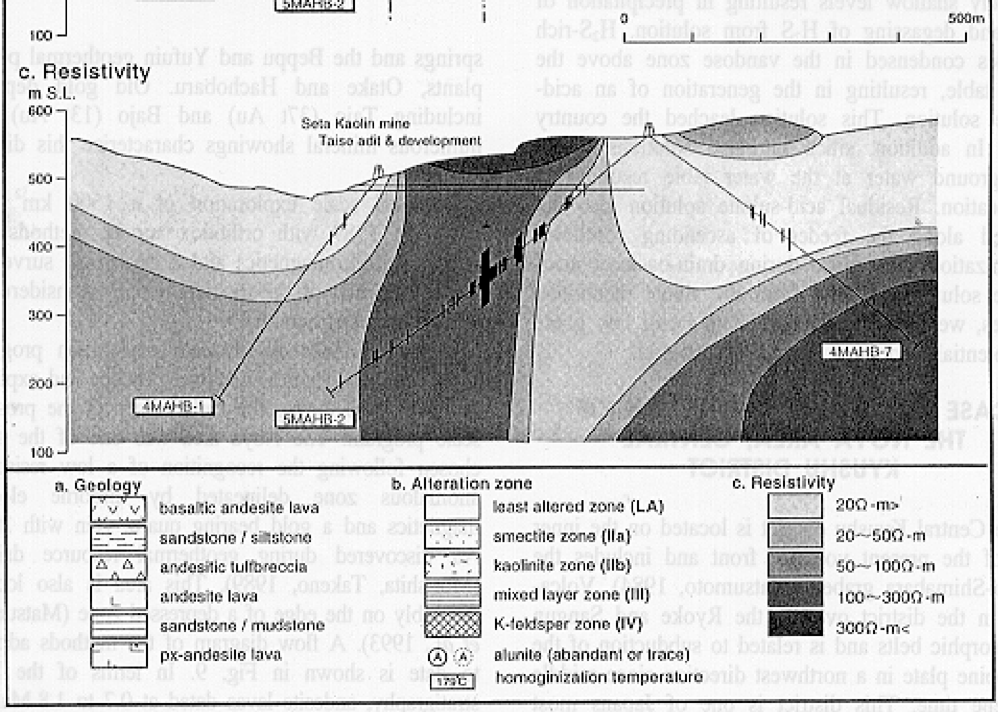

Fig. 7. Geologic cross section along the drill holes in the Seta area revised from Yamamoto (1995).

Method		1989	1990	1991	1992	1993	1994	1995
Geological Survey		—						
Geochemical Exploration	Rock	—						
	Geo-gas	—						
	Radon			—	—			
	Hg gas in soil	—		—	—			
	Soil	—		—		—		
Geophysical Exploration	Airbone electromagnetics	—						
	Schlumberger	—	—		—			
	CSAMT			—		—		
	Resistivity Tomography				—			
	Resistivity Image Profiling						—	—
Drilling			—		—	—	—	—

Fig. 8. Distribution of the selected survey area and gold deposits in the central Kyushu district.

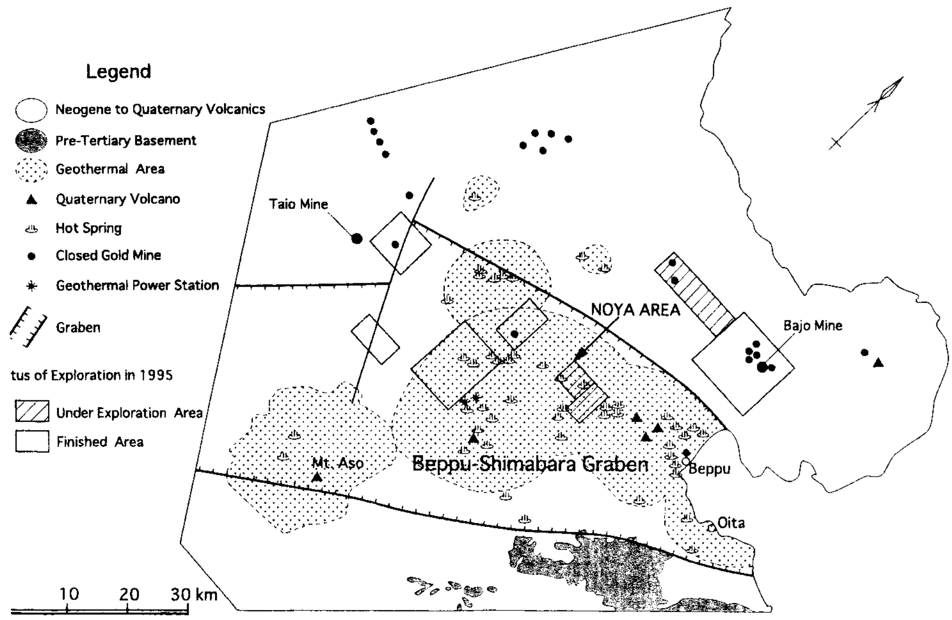

Fig. 9. Exploration methodology applied to the Noya area, the central Kyushu district.

of late Pliocene to Pleistocene and pyroclastic flows from the Aso volcano (MITI, 1990). Both hot and cold springs are known in the area and in low-lying sections argillic alteration, silicification, rocks, silica sinter and quartz veinlets are distributed representing near surface expressions of geothermal activity. The clay mineral assemblages characterizing hydrothermal alteration zones at the surface, for example crystobalite-smectite and quartz-smectite, indicate relatively low temperatures of formation during fluid/wall rock interaction. Furthermore, various geochemical surveys located anomalous zones related to hydrothermal activity (Fig. 10). Rather high temperature zones where gold presumably precipitates was targeted. Geophysical surveys such as Schlum- berger and CSAMT were applied to the area simultaneously with a geochemical survey.

Analysis of the resistivity data suggests the existence of three distinct layers, that is, a high resistivity zone (> 100 ohm-m) near the surface which coincides with unaltered pyroclastic flow deposits derived from the Aso volcano, and a low resistivity zone (< 50 ohm-m) at shallow levels representing argillicaly altered rocks, and a medium to high resistivity zone located at deeper levels. This assumption was confirmed by drilling as shown in Fig. 11. Although structural control is not as apparent as that exhibited in the Seta area in terms of geochemical and geophysical anomalies, a drilling program was implemented with holes oriented in a N-S direction, perpendicular to the direction of presumed E-W flow of hydrothermal fluids. In total, 18 holes with total length of 7,600 m were drilled up until 1994 with several Au-

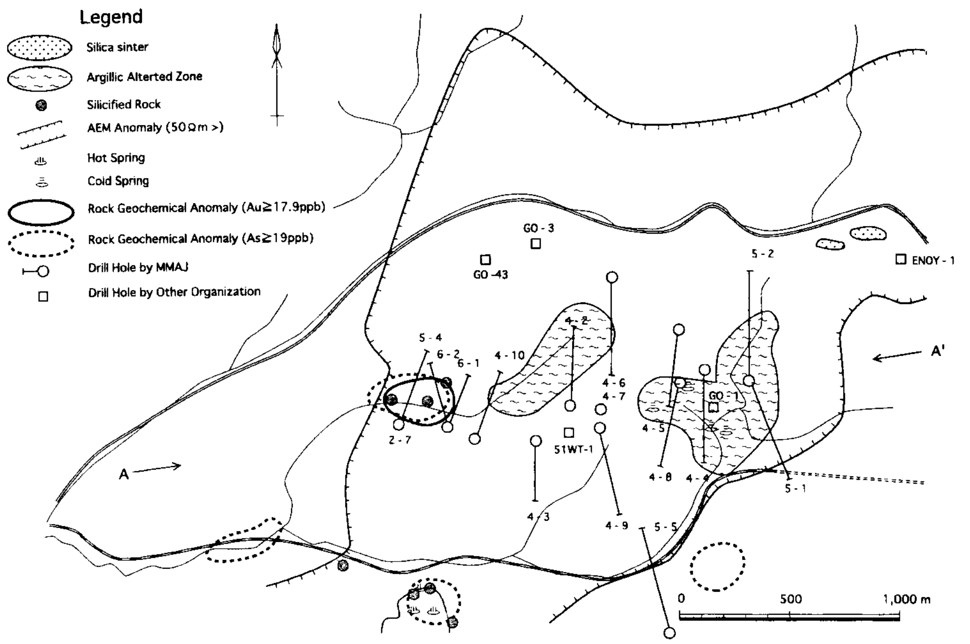

Fig. 10. Surface geological features, geochemical and geophysical anomalies of the Noya area.

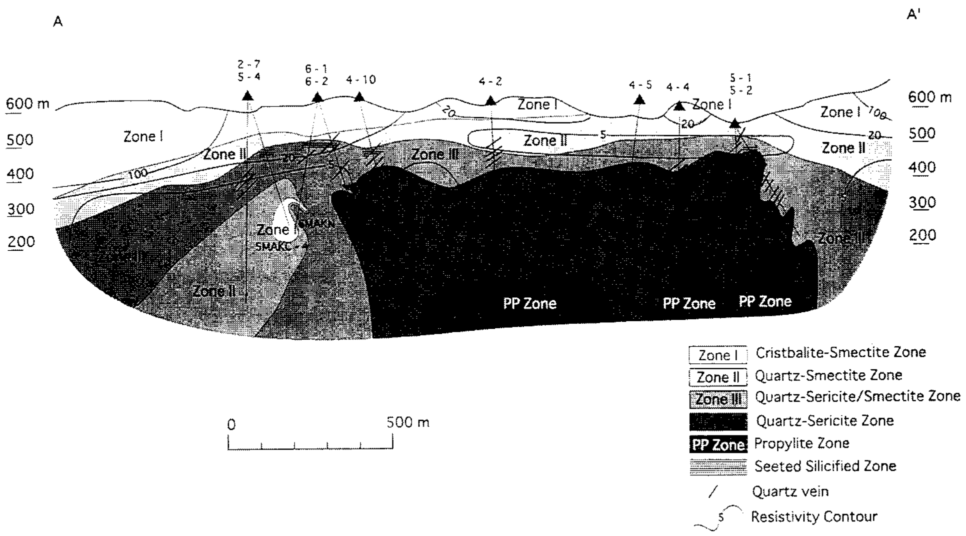

Fig. 11. Alteration zoning and resistivity cross section in the Noya area.

bearing quartz veins being intersected (Fig. 11). Hole 4MAKC-4 intersected a quartz vein 1m in width averaging 28.6 g/t of gold and 2.9 g/t of silver. It is clear that the location of gold mineralization is restricted to the quartz-smectite/sericite and quartz-sericite zone, at the lower part of the lower resistivity zone. In 1996, drilling will continue in this area in order to further delineate the zone of mineralization.

OUTLOOK OF DOMESTIC GOLD EXPLORATION

Generally speaking, the genetic concept for a particular style of mineralization is one of the most important factors used in an exploration strategy and especially at the initial stages of exploration. During these past two decades, geological information necessary for exploration of epithermal gold deposits

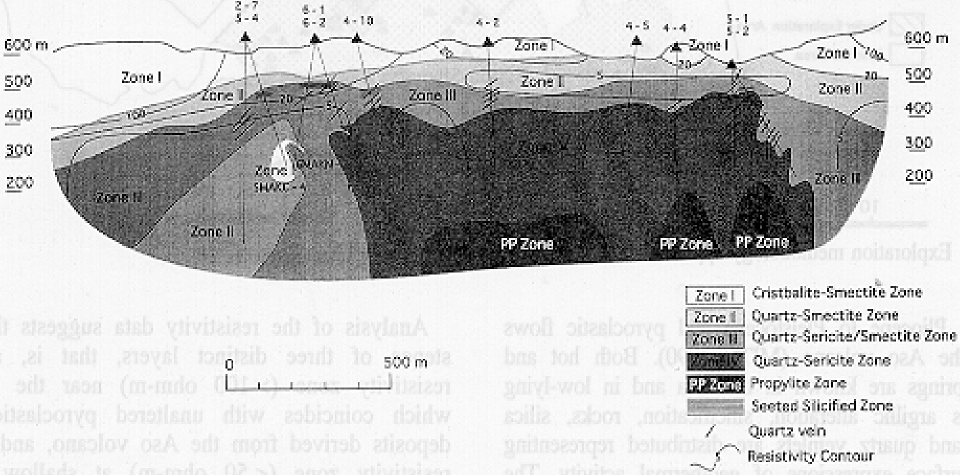

Fig. 11. Alteration zoning and resistivity cross section in the Noya area.

has accumulated, not only through active exploration and development of mines in the Pacific rim region, but also through research and exploration of active geothermal systems such as Taupo, New Zealand (Henley, 1985) and Steamboat Springs, Nevada, U. S. A. (Silberman, Berger, 1985).

If gold mineralization such as that described previously in the Seta and Noya areas had been discovered more than 20 years ago, it may have been developed. However, given today's economic climate in Japan, it is estimated that mineable grades and volumes of gold are around 15-20 g/t and 15-20 t, respectively. In order to mine such a low grade deposit, low in terms of Japanese standards but moderate to high grade in terms of foreign standards, new excavation and recovery technology operating at lower costs should be developed immediately. Technology involving gold extraction by thiourea rather than cyanide has recently gained more attention and research effort (Nakahiro, 1992). In conclusion, we are confident and optimistic that the promising new mineral showings in the Seta and Noya areas will become new gold mines in the near future.

At present, epithermal gold deposits are the only deposit among non-ferrous metal deposits which are capable of being operated economically under the current economic circumstances in Japan. In the course of exploration activities by the Metal Mining Agency of Japan, the Hishikari gold deposit with the highest recorded grade in the world was discovered. The mining activity of the Hishikari deposit by the Sumitomo Metal Mining Co., Ltd. contributed significantly to their ability to investment in foreign mining activities such as Morenci, U. S. A. and La Canderaia, Chile (Sudo, 1993). This is a good example of how a semi-government organization such as the MMAJ can play a major role in domestic mineral exploration.

Exploration for economic epithermal gold deposits in Japan will continued until the probability of their existence turns out to be zero.

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최근 일본의 금 탐사동향

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요 약 : 안정적인 천연자원의 공급을 통해 오랫동안 국가산업화에 이바지해온 일본의 광산산업은 산업구조의 개편에 따라 하향추세를 맞아 현재는 세 곳의 주요 광산만이 가행중이다. 최근 경제사정의 변화로 새로운 비금속광상의 개발이 어려워짐에 따라 매장량과 품위에 있어 경제적 가치를 갖는 천열수금광상으로 관심이 옮겨가고 있는 추세이다. 1970년대 후반의 급격한 금가격 상승은 환태평양 지역의 천열수금광상에 대한 지질학적 정보와 이해를 증가시키는 역할을 했으며, 특히 판구조론의 확립과 더불어 지열수계와 화석천열수계의 대비라는 가장 중요한 발전이 이루어졌다. 1988년에는 광산협회에서 천열수금광상의 개발을 목표로 일본내 19개 지역의 탐사를 인가했으며, 1989년부터는 준정부기관인 금속광업국에서 이 지역들의 금탐사를 수행해왔다. 광상성인에 관한 신개념과 새로운 탐사기술로 유망한 금광화대가 발견되어 왔으며 개발이 진척된 곳은 홋카이도 북부의 세타지역과 큐슈 중부의 노야 지역이다.