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POTENTIAL ENVIRONMENTAL AND SOCIAL IMPACTS OF SMALL SCALE, RURAL GEOTHERMAL DEVELOPMENT

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ABSTRACT

All too frequently, environmental and social issues are ignored or given low priority in the early phases of geothermal development. However, recent studies and exploration of small scale (< 5 MWe), rural geothermal development potential in Eastern Indonesian have established baseline data to assess the potential environmental and social impacts if such developments progress to production stage. These studies also provide comprehensive environmental and sociological monitoring programmes and recommendations to be implemented. The most important environmental issues faced in these small scale developments relates to the abstraction of water from streams and rivers, and reassignment of land. However, these impacts are somewhat mitigated due to the small 'footprint' of the development and the short period over which exploration and drilling are carried out. Sociological impacts are harder to assess and are more varied. Therefore effective participatory consultation with local inhabitants within their communities prior to exploration and later throughout the development phase is extremely important. Many issues relate to the lack of opportunity for involvement or 'spin-offs' for the local communities. Again, these can be mitigated by employing local people on the project and creating cascaded uses of the geothermal fluids. In such cases the high temperature resource can be used for power generation while the low temperature waters or condensate may be suitable for crop drying, timber drying or tourism. Small scale, rural geothermal developments present an opportunity in which many varied groups and communities can benefit with minimal detrimental impacts on either the environment or the local inhabitants.

1. INTRODUCTION

One of the main aims of small-scale (< 5 MWe) off-grid geothermal developments is to provide power for rural and isolated communities which are dependent on imported fuels for power generation. These small-scale developments have traditionally not been viable due to high start up costs in relation to the MWe output. However, recently there have been concerted efforts to minimise these costs (e.g. improved drilling technology, modular plants etc) to make such developments attractive to governments and IPPs.

In recent years there have been a number of pre-feasibility and feasibility studies carried out on geothermal prospects in Eastern Indonesia funded by the New Zealand Ministry of Foreign Affairs and Trade (MFAT). These studies were focused on providing power to rural communities far away from any distribution network. These studies not only include scientific reconnaissance and investigations, but also sociological and environmental impact assessments. Three areas which have been investigated recently in Eastern Indonesia are: Ulumbu Geothermal Prospect, Flores Island; Hu'u Geothermal Prospect, Sumbawa Island and Sokoria Geothermal Prospect also on Flores Island (Figure 1). Each area has its own unique features and potential but they have a common link where impacts of development are assessed on an environmental and sociological level. A brief summary of the three different fields follows, then a description of how the sociological and environmental assessments were carried out whereby the main problems and possible effects are identified.

1.1 Ulumbu Geothermal Prospect

An economic pre-feasibility study at the Ulumbu Geothermal Prospect on the island of Flores (Figure 2) was commissioned in 1987 by the Ministry of External Relations and Trade (MERT now MFAT). This was followed in 1989 by a technical, environmental and economic feasibility study for a 3 MWe power development. The Indonesian National Electricity Company - Perusahaan Umum Listrik Negara (PLN) commissioned the University of Nusa Cedana to carry out an Environmental Impact Assessment study of the proposed Project in accordance with Indonesian Government requirements.

Phase II (drilling) was proposed and funded by PLN with MERT assistance in the early 1990's and drilling of three successful wells was completed in 1996. MERT commissioned the NZ Department of Industrial and Scientific Research (DSIR) Social Science Group to carry out a social impact assessment study during the period October - November 1990. Subsequent environmental and sociological monitoring activities were carried out during the Phase II Project period (1991 - 1996). Completion tests and geochemical monitoring were carried out in 1996, however, the Plant Construction Phase of the Project (phase 3), has not yet been initiated due to the economic crisis in Indonesia.

1.2 Hu'u Geothermal Prospect

The Hu'u region of Sumbawa Island was selected by MFAT, in collaboration with the Government of the Republic of Indonesia, in 1997 for a feasibility study to assess its potential for small scale geothermal development to supply the electricity requirements of the eastern part of Sumbawa. The studies included scientific review and exploration, analysis of power requirements and a review of sociological and environmental implications for geothermal power development. The study teams spent considerable time holding meetings and individual discussions with village officials and villagers.

The geothermal features at Hu'u are dominated by the high volume low pH saline hot springs located on the south coast at Limea (Figure 3). Integrated interpretation of available geological, geochemical and geophysical data has shown no strong indications of any current high temperature hydrothermal resource at Hu'u (GENZL, 1998). There has been no further interest in this resource since the study was completed in 1998.

1.3 Sokoria Geothermal Prospect

The Sokoria region of Flores Island was also selected by MFAT in 1997 for a similar feasibility study as for the Hu'u resource and both areas were reviewed and explored at the same time. There are over 40 thermal features within the resource area including three spectacular high-elevation warm crater lakes at Keli Mutu (Figure 4) (GENZL, 1998). Keli Mutu is an active volcano and last erupted in 1968; it is also a national park and tourist attraction. As with Hu'u, there has been no further interest in Sokoria since the study was completed in 1998.

2. WHY SMALL SCALE, RURAL GEOTHERMAL DEVELOPMENT?

Demand for electricity in developing countries is expected to grow rapidly in the coming years. Providing better electricity supplies to rural people will contribute to that growth. The World Bank currently considers 5 MW plants as "mini-geothermal" but there is a significant market niche for much smaller units – down to the 100 – 1000 kW range. In remote areas, far from the utility grid, villages and facilities such as hospitals can replace their diesel generators with small-scale geothermal power plants.

Many people in rural areas who do not have electricity are willing to pay to get it. The rural poor often spend 10-20% of their disposable income on relatively costly energy services eg. diesel for power, kerosene for light, dry-cell batteries to run radios, and car batteries to run TVs. There is also a use for the power besides household use eg. small agro-enterprises, district heating/ cooling etc (Battocletti, 1998).

The local population must be a stakeholder in the project for it to be successful. They can provide the best information and insight on rural energy issues. Cooperatives, NGOs (Non-Government Organisations) and community organisations can be highly effective vehicles for supporting the delivery of energy services and managing the resources. Small developments can bring employment and wealth to local community, providing new skills and thus incentive for people to stay in the villages rather than work in the cities. There can also be spin-offs for local community eg. crop-drying, fish-drying, improved water supply facilities

Electricity sector reform is transforming the potential owners and operators of small geothermal projects from public utilities to IPPs. Reform is intended to improve the overall economic efficiency of the electricity sector and may open new opportunities for small geothermal projects in this more competitive market (Vimmerstedt, 1998).

3. OBJECTIVES OF ENVIRONMENTAL AND SOCIOLOGICAL IMPACT ASSESSMENTS

The introduction of geothermal project activities within close proximity to rural communities may contribute to changes in peoples' lives as well as their surrounding environs.

The social impact assessment identifies socio-economic baseline data and the potential for social and human settlement effects, and advises on avoidance measures to mitigate negative impacts of any future energy resource development. Similarly, the environmental impact assessment also identifies potential risks and possible benefits from such a development and is also useful in establishing baseline conditions and an environmental management plan prior to any future development.

An all too frequent failing of projects is the non-execution of environmental and sociological guidelines and recommendations established in the early phases of the project. Policy requiring that guidelines and recommendations be established (Environmental and Sociological Impact Assessment Studies) is in place, however, policy requiring implementation of the recommendations seems to be lacking, and most often the requirement for budgetary provision for implementation of these recommendations are totally ignored.

4. APPROACH AND METHODLOGY

4.1 Sociological Impact Assessment

A broad consultative approach was taken as expectations and concerns from the local communities did not want to be unnecessarily raised if the development did not eventuate. If a future proposal were to be considered, a more participatory approach would be required to discuss it. And if it was deemed that no project was viable, then an explanation to the communities involved in the study was recommended. This approach was applied to all three geothermal prospects previously described.

Consultation took place with governmental officials, local administrators, key informants in the three different regions and villagers living close to the resource. Observations were made relating todaily life, activities and development in the villages, tourist areas and general district. Specific sector interests were considered for analysis by gender, age, ethnicity and religion. With the Ulumbu project there has been more consultation and assessments because the project has moved towards the power plant phase.

4.2 Environmental Impact Assessment

The approach taken for the assessment of environmental impacts is first to describe the general nature and characteristics of the environment around the geothermal project and then to outline some of the effects and expected impacts due to development. Because of the complexity of the interactions within environmental systems, assessing the full nature of those impacts, and the likely consequences of further impacts, is extremely difficult; the evidence is however, that it is likely to be deleterious.

The general approach has been to describe the environment in terms of a series of interconnected systems - starting with physical parameters (such as climate), then biological systems (e.g. flora and fauna), followed by a comment on the social system. These systems have had the project superimposed upon them. The interactions between these different systems are numerous and complex.

The important point is that in all three areas the ecosystem was not in equilibrium prior to the onset of the feasibility studies.Changes in the types of land use and a loss of forested areas has been on ongoing process and has been, and is, bringing about rapid changes to the landscape.

5. POTENTIAL ENVIRONMENTAL IMPACTS

The potential environmental impacts that were identified are listed below - these direct and indirect impacts are common for all three areas studied. As only the Ulumbu field has progressed to the exploration drilling phase, the impacts will be discussed in relation to this field.

Direct Impacts:

- Air emission effects to human health, agriculture, and native wildlife and vegetation
- Increased noise and vibration
- Change in surface water and ground water quality and quantity
- Thermal and chemical shock to aquatic organisms
- Vegetation removal and habitat loss
- Visual impact on the landscape

Indirect Impacts

- Increased vegetation clearance due to improved roading access

The Ulumbu site was visited by an environmental scientist prior to, and again after, drilling operations. The purpose of the site visit was to establish a baseline of the surrounding environment prior to commencement of drilling operations. Another reason for the visit was to provide specific recommendations to reduce or mitigate the likely effects from the planned drilling activity. At the same time, the opportunity was taken to observe current trends and activities within the watershed.

The Ulumbu area is becoming increasingly intensively cultivated and rivers are extensively used for crop irrigation, especially rice. Extensive areas of natural forest exist in the region at the upper watersheds but these are being encroached upon by people extending their agricultural practices or moving into the area. The land is steep and although the volcanic soils are relatively fertile, significant amounts of soil erosion is occurring. There is a significant amount of cash cropping being initiated, especially vanilla orchids, coffee, vegetables and fruit.

The project used only a limited amount of water from the local river (Wai Kokor) for a relatively short period of time during drilling operations. Given the great dependence downstream for irrigation of crops to the level that the local rivers rarely actually flow to the sea, any sustained abstraction from the streams was considered cautiously. The natural hot springs discharge a quantity of brine into the Wai Kokor which can be detected at significant distances downstream. The local people do not like the taste. Ongoing monitoring was recommended to observe possible changes in the influence of the natural hot springs due to steam abstraction for power.

The construction of a small dam above the natural hot springs had been carried out manually to minimise any impacts on the surrounding landscape. Had bulldozer access been made then there were very strong concerns of promoting access to that side of the valley and subsequent expansion of agricultural activity (deforestation). Although there is a "well-trodden path" because of construction activity the effect is only short term, unlike the consequences of a bulldozed vehicle track.

The water supply pipeline from the dam to the well pad had also been hand-laid and is not permanently set up since it will be redundant after the completion of drilling. A smaller line could be installed later to meet the needs of the power station. A weirbox was later installed to enable estimates of the relative amounts of water being abstracted and the normal volume of water.

Two pad sites were cleared in the event of either or both being used. The area comprised approximately 100 x 70 m per site. Reconstruction of roading and bridges from Iteng – Ponggeok – Lale was carried out. As Lale was the nearest village to the Ulumbu site (2km distance) a road diversion was created so the increase in traffic would bypass the village. Compensation was paid to the landowners.

The hilly upland terrain has meant that both of the pad sites have steep edges that are susceptible to severe erosion. This seems to have been a particular concern with the site that was eventually chosen for drilling operations where the bank was likely to erode and deposit significant quantities of sediment into the Wai Kokor). Such erosion would also rapidly reduce the effective size of the pad itself. Efforts to try to reduce this risk have been carried out by the construction of tiered gabions. While the supply of stone material for the construction of the gabions has been a lucrative activity for local farmers little effort to vegetatively stabilise the pad sites was evident. The biostabilisation of the pads and other road cuttings is seen as an important remedial activity for the project. On gabions and areas with steep slopes there needs to be more than just surface covering by grasses. Trees need to be planted and rapid growing legume species would seem to be ideal. For this to be successful a nursery should be initiated in the area behind the base-camp. The nursery should also start to grow other species for stabilisation/restoration of areas. These could include some fruit tree species and especially some creepers to quickly cover the slopes. The reasons behind fruit trees being recommended are that local residents currently grow a wide selection and value their produce, and because of this they are likely to take an active interest in their successful establishment. The local residents are also more likely to continue to ensure the plants survival after the completion of the project.

Concerns were raised over the effects of release of noxious gases and high noise levels during the drilling operations and during the well testing programme. Throughout the drilling operations the site was equipped with a sophisticated automatic gas monitoring and alarm system, and regular operation safety drills were carried out in accordance with

National and International safety regulations. The drilling area was clearly sign posted as a dangerous and secured area, and security guards are posted 24 hours a day.

The well testing programme was limited to 6 vertical discharge episodes, with a maximum duration of 5 hours, and one long term continuous horizontal test lasting 7 days. As was expected the vertical, unsilenced discharge tests were dangerously noisy at the well site, and extremely noisy at distances of up to 1 kilometre. All local residents were provided with disposable earplugs and were prevented from approaching the well site during these short term tests. The long term horizontal discharge test was carried out using a separator muffler which reduced the noise levels somewhat. The location of the well site within the Wai Kokor valley shielded all except one non-permanent residence or "guard" house. At the nearest kampung the noise of the long term discharge was discernible at only background levels. As indicated above, this test was limited to a period of only 7 days.

The fluids produced from Wells ULB-02 and ULB-03 have proven to be dry steam, and reservoir engineering interpretations indicate that these wells are most likely to continue to produce dry steam. Effluent brine disposal, and the problems associated with brine pollution of waterways will not be an issue.

6. POTENTIAL SOCIOLOGICAL IMPACTS

Implementation of the following aspects will be required to prevent and mitigate negative impacts and maximise the beneficial aspects of geothermal project development activities. There are six issues around which recommendations for managing potential negative social impacts are made:

- Satisfactory and constructive negotiation on land use, acquisition and compensation
- Assessment of sources, utilisation and protection of water supply
- Appropriate placement of project baseline
- Health and safety standards and precautions
- Gender and situational specific analysis of impacts on women/men and community development
- Consultation with local communities and special interest groups e.g. if the project has the potential to displace people

The initial sociological study of the three areas was kept 'low key' as the study team were reluctant to undergo a full participatory study and run the risk of raising expectations or concerns that a project would eventuate. However, as the Ulumbu project has progressed, the main issues raised in the initial study can now be reassessed and real impacts quantified.

Concerns were expressed in the initial feasibility study at Ulumbu, that the influx of personnel associated particularly with the drilling operations, would place a considerable strain on the limited health services provided to the area, and upon water supplies and sanitation. The entirely self sufficient nature of the drilling operation, and the location of the drilling camp well away from existing populated areas almost totally negated these effects. Adverse health effects were avoided by construction of sealed septic tank sewage systems both at the drilling site, and at the drilling camp, and there was total containment of all drilling effluent at the drilling site.

An MFAT funded water supply system for local villages has significantly enhanced hygiene and sanitation. This "spin-off" project has not only provided clean water and washing facilities in the area, but also water flushed toilet facilities connected to properly designed and constructed septic tank systems. A training programme was introduced which addressed the use of water, hygiene and sanitation, and the operation and maintenance of the system. Since completion of this project in October 1995, these facilities have been in constant use. Whilst it is too early to be able to report statistics on the reduction of hygiene and sanitation related diseases, it is quite evident that the quality of life in these villages has been considerable enhanced.

A highly respected, local and independent specialist (Dr Ataupah) was used specifically in an effort to ensure that project information was not conveyed in a manipulative manner. Such an approach would have defeated the purpose of consultation which was to inform and to identify concerns and attempt, as far as possible, to ensure that the project "fitted in" with the host communities.

The long history of involvement with this project by Dr Ataupah has meant he acted as a community liaison person. Significant merit for the success of the consultation lies with Dr Ataupah because of the following key reasons:

- His ease of communication to all parties (including fluency in the Manggarai language), so that the effort needed to obtain or provide information was not an impediment.
- His credibility within the region. By this is meant that he is viewed as not being the project proponent but a diplomatic channel between the community and the project.
- The fact that when concerns were raised by the communities, they were acted upon (e.g. road by-pass of Kampung Lale and land compensation).

Consultation activity has on most occasions involved GENZL's project Engineer/Manager and specialists attending the meetings both to provide information and assess community attitudes. It is planned that this consultation process, and the utilisation of Dr Hendrik Ataupah will continue throughout the Phase III, the Plant Construction Phase of the Project.

7. ENVIRONMENTAL & SOCIOLOGICAL MONITORING PLAN

Recommendations:

- Watershed management study
- Re-vegetation nursery program
- Direct uses for waste heat

Unfortunately in the case of the Ulumbu Mini Geothermal Power Project many of the early recommendations were not implemented. However, it is gratifying to be able report that funding made available from the MFAT contributions to the Project did enable a comprehensive environmental and sociological monitoring programme to be implemented, as well as two significant "spin-off" social development projects to be executed. These two "spin-off" projects were the installation of a water supply and sanitation system to the Kampung Lale and Kampung Wewo areas; and the construction of a section of road around Kampung Lale to divert all traffic moving to and from the Ulumbu site.

Despite the existence of numerous agencies and management authorities in Indonesia, the real managers of the land are local farmers and villages. Constrained by poverty and technology, their pursuit of arable land, food, and fodder has profound effects on the land and water resources of both upland and lowland areas. Mounting pressure on scarce land and forest resources, stemming from rising human and animal populations, is leading to severe environmental degradation throughout several regions of Indonesia. While not so acute in Flores, the same pattern is likely to follow.

Too often geothermal projects, while widely thought of as environmentally friendly, are not integrated within the local community and environment. Instead, a project tends to be superimposed on top of it, in that its development and operation occurs largely in isolation from the local people and the local setting. Relatively few people gain long-term employment (and then usually menial tasks) and the power primarily goes to city industries etc.

A watershed management study is needed to investigate how farming activities can continue without sacrificing the environment. There is the possibility of using the harnessed geothermal resource after power production for crop drying or processing. Such an enterprise would involve the local people in an activity that they are directly familiar - farming, while at the same time enabling them to improve their living standards. It is an opportunity for the local community to directly benefit from the energy resource.

This is consistent with the World Bank finding that the principal emphasis in watershed management must be on solutions that raise incomes. These are often not only the easiest to put in place but they may also help to deal with other problems. For example, undertaking soil and moisture conservation practices on farms will increase food output and raise incomes, and will also have an incidental but helpful effect on downstream sedimentation. Another possibility that could be investigated would be the use of the spent steam for the development of a series of hot pools as a tourist resort.

As mentioned earlier, the sedimentation level of the river is likely to be blamed on the activities of the power project. Of greater concern is the likely effect of deforestation on the flow rate of the streams. It is widely known that deforestation can lead to changes in the hydrological pattern of stream flows and in this particular case the concern lies with reduced flows during dry periods. There is a great dependence on crops irrigated by the local rivers. Any crop loss due to a drought and insufficient water to irrigate, would probably raise suspicions about the projects' influence while the real cause is likely to be the gradual cumulative effects of watershed deforestation.

8. FACTORS CONTRIBUTING TO SUCCESS AT ULUMBU

The following factors were considered to have played an important role towards the success of the Ulumbu programme to date:

- High profile consulting staff presence at the area. Senior GENZL staff were frequently at the project site and stayed for substantial periods of time (i.e. several months). The efforts of genuine input and concern for a positive result were visible.
- High profile presence of senior managers. The visits by both senior GENZL staff, MFAT and New Zealand Embassy personnel and other officials (such as from World Bank), also conveyed a genuine interest in the project, the area, and community.
- Flexibility of the programme allowing local concerns to be taken into account, a responsiveness to issues raised and a participatory community based problem solving approach. Two obvious examples were the supply of domestic water to the villages in proximity to Ulumbu, and the road diversion around Kampung Lale.
- Use of a well-respected local consultant to address the local communities with what the social concerns were and to help disseminate information about the various activities of the programme.
- Professional standards. Project staff were seen working long days and seven days a week

This Ulumbu project offers the potential to serve as a role model in this region.

9. CONCLUSIONS

The environmental and sociological concerns outlined above have mainly dealt with the early stages of development. Future key concerns associated with power transmission corridors and power generation plant have not been covered.

The key question to be addressed is the level and extent of support a project places into the wider ramifications of development such as potential for social and economic changes and watershed management. There is a critical need for the clear delineation of the fact that either a project becomes "part" of the community or is "apart" from the community

The support of a watershed management study, establishment of a re-vegetation nursery and programme, and possible direct uses excess heat for community crop drying would strongly signal a desire to become part of the community.

Solutions are required which give priority to the identified development needs of the people and include them in environmental planning and rehabilitation. In order to get the support of the communities there must be consultation, information, education and evidence that the lives of the rural poor are to be improved as a result of the geothermal development. Their agricultural systems may have to be intensified even further in order to reduce the amount of land necessary to support existing communities. Off-farm employment may have to be increased to compensate FOR loss of land and contribute labour, skills and income locally. Opportunities for education, training and micro-enterprise and small business development could be created for the community in off-farm work. This could be achieved by proactively including the communities in contracts to provide support services with improved and fairer marketing schemes instituted. Resources, such.as family planning and health services, which are available to the project could extend to the communities children and or families during the course of the project with an aim for the communities to develop them in a self sustaining way once the project development phase is completed. The opportunity for the communities affected to access affordable electricity, as well as education and information on the means to utilise it productively, should always be an outcome of small scale rural geothermal development.

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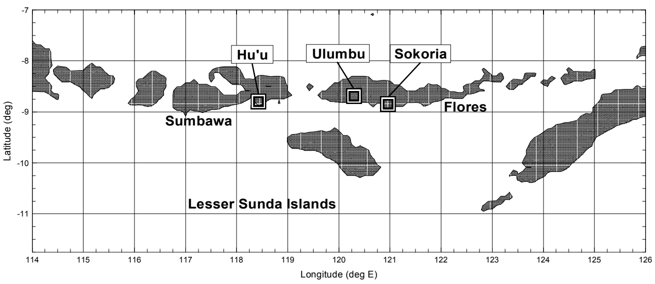

Figure 1. Location map of Ulumbu, Hu'u and Sokoria - Eastern Indonesia


Figure 2. Ulumbu Geothermal Prospect looking up the Wai Kokor valley, fumaroles in background right.

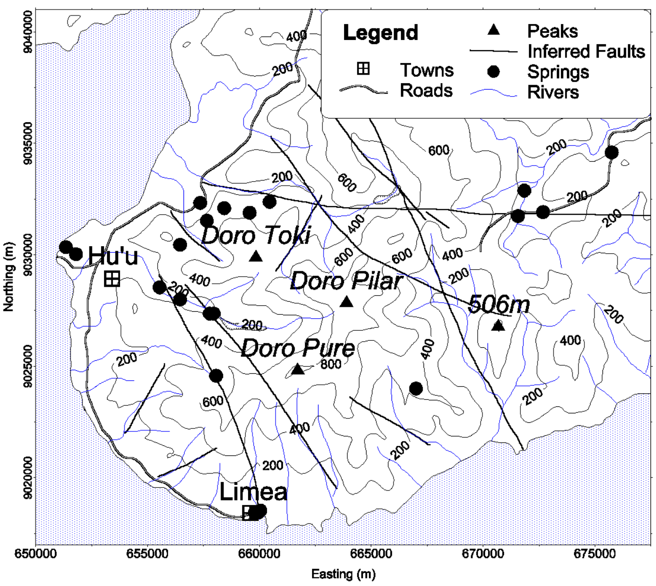

Figure 3. Hu'u Geothermal Prospect

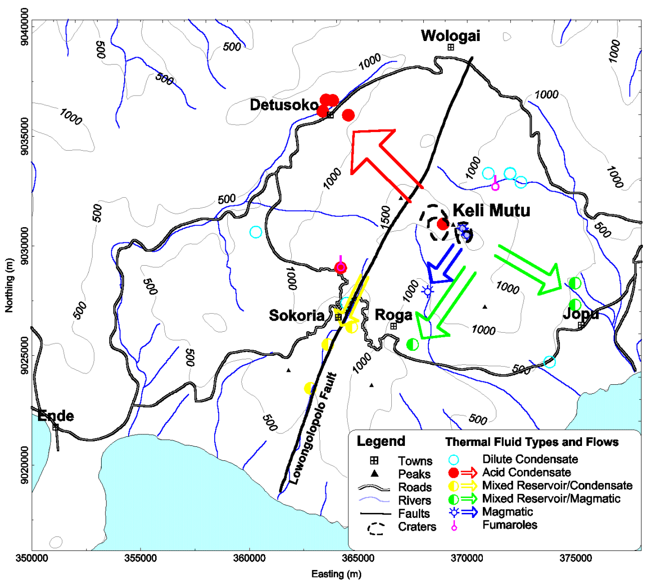

Figure 4. Sokoria Geothermal Prospect