Beds that host the Stawell gold deposits in the western Lachlan Fold Belt. My position is funded by an ARC SPIRT grant and Stawell Gold Mines, and as the only volcanologist in the department, represents the first steps for volcanological research at Melbourne.

Sulfidic mudstones, referred to locally as volcanogenics, are the host for mineralised zones with the highest gold grades at Stawell. However, despite the importance of primary lithology on the distribution of gold at Stawell, the lateral and vertical distribution of lithofacies such as the sulfidic mudstones are poorly understood. My work will attempt to establish the facies architecture of the Late Cambrian to Early Ordovician successions, in order to better predict the location of high grade ore shoots at Stawell. This will involve detailed logging of drill core and mapping of underground exposures from selected sections.

Despite the small size of the volcanology team currently at Melbourne, it is in an expansionary phase that will continue until it has reached market domination. This is anticipated to be 2007 (look out Monash, CODES, etc!).

THE ROLE OF GEO-ENVIRONMENTAL STUDIES IN VOLCANIC GEOTOURISM PROJECTS

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For many development projects it is necessary to carry out a preliminary geo-environmental study before setting up the project and to consider the final recommendations of this study before, during and after the project. This will lead to attaining so-called "sustainability": achieving development targets side by side with eco-equilibrium. Therefore, a keen demand for Environmental Impact Assessment (EIA) reports will be put on the top of national and regional investment agenda. The World Bank (WB) defines the purpose of EIA as to *"...ensure that the proposed development is environmentally sound and sustainable and that any environmental consequences are recognized early in the project cycle and taken into account in the project design*."

Nowadays, many international donators' agencies (e.g. WB, EEC, etc.) would approve loans and grants to developers with the stipulation that project owners include a comprehensive environmental study, documented scientifically, together with their applications. Indeed, the study that best predicts, with high accuracy, the degree of negative impact of the project on the environment and suggests the practical mechanisms to mitigate these adverse effects will surely win the biggest loan and praise.

As volcanoes are considered a natural wealth resource, usable and exploitable, a geo-environmental study (GES) would have an outstandingly helpful role for all kinds of businesses using volcanoes including tourism. The volcanic geotourism industry, similar to other development industries, needs much geological and environmental information. The information collection takes a huge effort and is a very long procedure (given that volcanoes are very geographically remote places). Undoubtedly, a GES would assure the developer of a feasible and continuous project cycle with, potentially, a minimum of undesirable environmental impacts. On the other hand, a GES gives decision-makers a frank, thorough prediction of any possible future impacts that may result by running the new establishment along with "in-case" emergency plans to avoid the total loss of budget. Generally speaking, the main objectives of a GES in a volcanic geotourism project would likely involve:

A. Description of the resort project including information on: needs & alterna-

tives, initial design, screening, scoping and site selection,

B. Description of the measures envisaged to avoid, reduce and, if possible, remedy significant adverse effects. This includes: site-specific scoping, baseline survey, prediction, evaluation and preparation of EIA
C. Identifying the data required to assess the main effects which the resort is likely to have on the environment. This includes revision of EIA, consultation, planning decision, authorization & final design agreement.
D. Participating in implementation, construction, monitoring of compliance & impacts, auditing of performance.

The project owner of a volcanic resort needs to include many experienced professionals and experts from different disciplines and interests to work together as a team. GES teamwork could be subdivided into two main groups, each of them analyzing and collaborating in processing information with the other group so as to bring about a clear integrated evaluation of the entire project.

1. Geological team functions

Geologists would be fully responsible for all kinds of mapping including geologic, geomorphologic, topographic, tectonoseismologic, hydrologic and hydrogeologic, soil and land-use in addition to coastal and coral reef mapping in case of marine locations. Thematic maps are recommended in the early stages of the study (e.g. geohazard zoning, mineral provinces, etc.). Geologists apply modern methodologies to help them map an area (e.g. remote sensing/GIS and photogrammetry). The resulting study can really give the developer a general idea about the suitability of the study area, thus an initial consultation and advice by from geologist could save much money.

A team of geologists could also research the general geology of the volcanoes found in the resort area, defining and classifying their types, cones and eruption modes; the economic geology of exploitable resources like geysers, hot springs, solfatara and volcanic ash (e.g. scoria and tuff) which could be used for local agriculture, pumice for building isolation, etc.).

Air quality and atmosphere geochemistry monitoring - monitoring the concentration of natural air pollutants like toxic/corrosive and radioactive gases is of extreme importance. Substances resultant of volcanic activity such as monoxides, trioxides, HCl, HF and radon, if found above standard limits, could reduce the air quality and, consequently, the true value of the resort location.

Soil geochemistry tests - generally, in EIA reports, geologists need to record the proportions of the following most significant chemicals:

1. Major cations - Na^{+} , K^{+}, Ca^{++} , Mg^{++} , etc;
2. Major anions - Cl^{-} , $SO_3^{=}$, $CO_3^{=}$, HCO^{-}, etc;
3. Heavy metals - Fe, Mn, Cu, Cd, Zn, and Pb.

The soil geochemistry will assist in evaluating the suitability of the soil for agriculture, predicting the potential conditions of the soil should it become polluted and helping the expert to suggest a quick response mechanism to deal with/reduce the impact on the environment (emergency planning).

Hydrological & hydrogeological study of water resources available in the proposed area - it is necessary to quantify the water budget of the site, defining water quantity and quality standards needed for various human and industrial activities.

Geo-engineering study of raw-building materials found naturally in the area, their quality and suitability to the national building codes - geoscientists recommend which in-situ deposit can be used for construction, as they prefer to use the original materials derived from the area itself to accomplish so called *"environmental compat-*

ibility and smooth visual homogeneity". They believe that using in-situ deposits for local construction may reduce the visual disturbance in the surrounding environment. In addition, soil tests and geohazard recognition are important to civil engineers and architects for the virtue of defining and tracing critical structures (e.g. landslides, volcanic devastation zones, cavities, subsidence, etc.) to be avoided in the project design. Monitoring and tracing geothermal anomalies may assure a huge free source of renewable energy that could be utilized more efficiently if the developer applies modern technologies like hot rock geothermal energy or steam-powered geothermal heat stations.

Marine studies - in the case of volcanic islands, there should be a regional geological study of marine formations, coral reef distribution, coastal change effects, marine sedimentation processes and tidal modes. This study would research the best marina sites and safe sea lanes which are suitable to minimize the effects of man-made pollution (chemical, noise, etc.), assuring a strict environmental protection policy for the marine ecosystem.

Geological information would help to design a feasible Emergency Action Plan (EAP) that manages a quick response in the face of natural disasters and suggests the correct avenues of risk management programs applicable for both the developer and the local community. It is worth mentioning that the appraisal of risk on and near any volcano depends largely on a knowledge of past behavior of the volcano. This also depends on:

1. the recorded history of eruptions, and

2. a geological study of the composition and structure of the cone (Bolt *et al.* 1975)

2. Environmental team functions

Environmentalists would also be called to measure the environmental aspects of the project area, including the following qualities:

- Ecology & site characteristics of the area including physical, biological (faunas & floras) and socio-economic conditions;
- Physical, chemical & bacteriological testing of soil, water and air samples collected from widely-spaced locations in the resort in order to define the baseline standards for sanitation;
- Identifying those biomes that are critically sensitive critical to human activity or that are vulnerable to extinction. Build up a proper policies and methodologies to ensure proper protection for endangered species;
- Monitoring pollution in the hydrosphere, lithosphere and atmosphere and manage practical ways to minimize adverse effects on the ecosystem;
- Logging all meteorological changes and their effects throughout the project cycle such as: daily temperature, atmospheric pressure, wind direction and velocity, humidity ratio, precipitation, flooding, etc. Computerized records and stationary instruments will be of great use in weather forecasting for the developer and the tourist as well;
- Monitoring noise-level anomalies in the surroundings that could reduce the development's value. Environmentalists should set up many appropriate mechanisms and solutions to relieve unusual noise levels in order to make the resort more comfortable;
- Designing water treatment plants using modern technology that attain the best methods of by-product management, water purification and sewage treatment. In volcanic resorts, as they are remote, limited and poorly civilized places, it is recommended to adopt new technologies that re-use waste materials in a beneficent way assuring minimum

levels of pollution discharged to the environment;
- Ensuring a clear strategy for solid waste-disposal on the grounds of achieving maximum environmental safety and soundness of practice;
- Planning suitable technologies for using any potentially renewable resources found, if any, in the project area such as wind, solar, biomass energy, etc.;
- Auditing and controlling the architectural design elements put forward by the developer and assuring its compliance with the specific standards mentioned in the EIA report;
- Establishing a Self-Defense Unit (SDU) that clarifies a cross-boundary policy in dealing with disasters (fire, death, etc.) through training and rescue management programs.

In addition, many other specialists are integral to preparing GES and EIA reports including engineers, economists and sociologists. It should probably go without saying that all these vital tasks are better integrated using proper information technology and database management which could continuously feed back input/output information in the master plan of the project. Geographic information systems and other software applications help in data renovation throughout the work progress so that decision-makers are free to deal with a flexible and dynamic system, allowing them scope to judge in conformity with the eco-equilibrium system. It also helps the developer to evaluate and possibly reduce the amount of property loss, if any, that may arise from uncontrollable natural disasters in the future.

In reality, volcanic geotourism projects are still considered clean and environmentally sound businesses with the least harm to nature in comparison to other projects. This is related to reasons such as the unlimited availability of natural raw materials, the unnecessary need for high tech to operate the projects and the limited direct human involvement, in some way or another, in the natural system of volcanoes.

GES is truly considered as a national and regional nature conservation plan, aware of the importance of natural heritage. It establishes a common language between man's ambitions and aspirations to more luxurious standards of living and his noble desires to maintain continuous, active balanced nature. It also works as a new means to establish understanding and remove old dread, resulting from inherited anger at volcanoes. In the end, GES will prove that man can go along in peace with volcanoes as natural partners in business, thereby attaining a steady state in the new paradox: *development against environment* that recent terminology calls *"sustainability".*

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ORIGIN AND SIGNIFICANCE OF THE QUARTZ SAND IN THE "SANDY TUFF" OF THE DIAMONDIFEROUS OLIVINE LAMPROITE DIATREME OF THE ARGYLE MINE, WESTERN AUSTRALIA

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The Argyle diamond mine is hosted by a Mesoproterozoic (1178 ± 47 Ma, Pidgeon *et al.* 1989) diatreme ("pipe") composed essentially of olivine lamproite pyroclastic rocks. The unusual feature of the pipe, besides its very high grade of diamonds, is the