

# **Natural Science Research in Zimbabwe**

**An Evaluation of SAREC Support for  
Research Capacity Building**

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**Department for Research  
Cooperation, SAREC**



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Sida Evaluation 97/14  
Commissioned by Sida, Department for Research Cooperation, SAREC

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Registration No.: SAREC-1996-0678  
Date of final report: January 1997  
Printed in Stockholm, Sweden, 1997  
ISBN 91 586 7471 3  
ISSN 1401-0402

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## **Acknowledgement**

The three members of the Evaluation Team would like to express their deep gratitude to project participants, university officials, Sida staff and other individuals listed in Annex 2 for their invaluable assistance. The Team members were not only given all requested information punctually, openly, and in a convenient form; they were also greeted with extensive hospitality by all involved in the projects, both in Zimbabwe and in Sweden. Due to this unique cooperative climate, the evaluation became both a pleasant and a valuable experience for the Team. Furthermore, the Team would like to thank Prof. Susan Jagner, Gothenburg, for valuable comments and suggestions.

# 1. Executive Summary

**The Evaluation.** The present evaluation of the impact and efficiency of Sida/SAREC (in the following called SAREC) support for natural science research in Zimbabwe was carried out during the last four months of 1996. The current agreement on bilateral cooperation between Zimbabwe and Sweden comes to an end in June 1997; one main purpose of this evaluation is to produce material for the decision regarding future support to natural sciences in Zimbabwe. Since individual inputs in the supported projects rarely are simply related to the individual project outputs, it has not been possible to perform a detailed cost/benefit analysis. Instead an overall evaluation of project outcomes (research capacity building and research results) in relation to project costs has been attempted.

**The Evaluation Team.** The three members of the Evaluation Team were: Peter N. Campbell (U.K., biochemist), Daniel Jagner (Sweden, analytical chemist), and Erik W. Thulstrup (Denmark, physical chemist, Team Leader). The three members made short visits to project activities in both Zimbabwe and Sweden during the period September - November, 1996.

**Background: Recent Financial Conditions in Zimbabwe.** The socialist reforms, which were introduced in Zimbabwe after independence in 1980, have in recent years been replaced by more pragmatic policies. In 1991, Zimbabwe started a structural adjustment process which involved heavy cutbacks in public expenditures, privatizations, devaluation and liberalization of currency and trade. As other areas in the public sector higher education and research have suffered as a result of the cutbacks. The adjustment process became even more difficult because of a severe drought in the region during the early 1990s but, contrary to the situation elsewhere in Africa, political stability in Zimbabwe has been maintained.

The economy still suffers from high unemployment, a large number of AIDS victims in the population, and a population growth of over 3% annually. In spite of high expectations for the economic development in the coming years, significant improvements in the conditions for research and higher education within the public sector do not seem likely.

**Areas Supported.** During the last eight years SAREC has provided support to four areas within natural science which are considered of particular importance for sustainable development in Zimbabwe. The four areas are:

- Protein Biotechnology,
- Chromite Mining and Ferrochrome Smelting,
- Groundwater Resources Development, and
- Environmental Chemistry

The support for these four projects has amounted to about SEK 25 million, or one third of the total SAREC support for Zimbabwe during the eight years.

**General University Support.** In addition to the direct support for the four projects, SAREC provides more general assistance to the University of Zimbabwe, especially the Main Library, where most research journal subscriptions are paid by SAREC, and the financial management departments on Campus, which cannot compete with private business for good accountants. The services of the financial departments in the University are still unsatisfactory and the incentive structure is unfortunate: Slow service in the central university administration increases its interest earnings, for example from SAREC grants.

**The University of Zimbabwe.** All four projects are located at the Campus of the University of Zimbabwe. The Chromite Mining Project is placed at the Institute of Mining Research (IMR), which is a pure research institute under the Faculty of Science, but funded by the Ministry of Mines, while the three remaining projects are placed in regular university departments. The University has strong academic traditions and the institutes hosting the project activities are all among the best in Africa within their respective fields. In particular the Chemistry Department has extensive amounts of modern research equipment, but finds it difficult to locate sufficient funds for its maintenance and use.

The recent economic cutbacks have dried out most domestic sources for public research support and researchers at the University are increasingly dependent on foreign sources. At the same time many university departments are heavily understaffed; this goes back to independence when a majority of the university staff left. The problem is difficult to solve; the natural science departments compete for new scientific talent with strong and active domestic industries and are often losing this competition. In addition, a number of new universities in Zimbabwe have a need to recruit qualified researchers and are also competing with the University of Zimbabwe for funds.

Management on campus is decentralized as in the Nordic countries. Deans and Department Chairpersons do not have extensive power; most decisions are made locally within individual projects. Although this strengthens local responsibility and reduces bureaucracy, a stronger involvement at the faculty level might be an advantage, for example in connection with the provision and monitoring of outside funding for research in the Faculty.

**Scientific Cooperation.** With the exception of the Environmental Chemistry Project, all projects have Swedish partners, defined in the agreement with SAREC. The resulting North-South cooperation is more "symmetric" than most; in particular, the partners in Zimbabwe have a high degree of financial responsibility which ensures a more complete research capacity building. Generally, the cooperation seems to be highly appreciated on both sides; in addition, the Zimbabwean partners are successful members of international networks in their respective fields and cooperate internationally with many other researchers.

The cooperation on Campus is not as efficient. Although there are several overlaps between the SAREC sponsored projects their cooperation is minimal. Opportunities for scientific cooperation on Campus are often not exploited; in particular the earth sciences have not been able to unite forces, although this would strengthen the whole area considerably. Nor is cooperation with industry as extensive as it might have been, especially in view of the fact that all four projects produce knowledge and training which is essential for important parts of the Zimbabwean economy.

**Scientific Success and Relevance.** The projects produce valuable research results and research training at a good international level. As indicated above, these outcomes are of considerable importance for the economic development of Zimbabwe. The Protein Biotechnology Project may help modernize Zimbabwean industry with important biochemical input. The Chromite Mining Project is not only able to support the large mining industry in the country, but may also be able to support industries which are based on the mining products. It also has started contributing to more environmentally safe mining practices. The Groundwater Resources Development Project may help solve the increasing problems within the country and region with respect to the supply of water for an increasing population and economic activity. Finally, the Environmental Chemistry Project is able to provide reliable and quantitative answers to questions of key importance in connection with the attempts to secure an environmentally safe economic development in Zimbabwe.

Through the four projects, research capacity is being built at a good pace and high level, both through formal degree programs at the University of Zimbabwe and in Sweden, through other training activities and research tasks, and through the experience gained through management of project funds in Zimbabwe. The cost effectiveness is estimated to be good compared with that in other, similar programs.

The present situation, with a high degree of research capacity but a shortage of funds and difficulties with the recruitment of young talent in the four projects, makes it both necessary and advantageous to gradually redefine the project targets. In particular, the projects will soon be able to take responsibility for research capacity building projects elsewhere, both in connection with the new universities in Zimbabwe and in a regional context. This may not only provide access to more scientific talent but may also justify continued, maybe even increased, funding.

**Development of Project Scopes.** It is satisfactory that within several projects a gradual change of project scopes has taken place in accordance with other developments, both within the project and in society. For example, in the Chromite Mining Project, environmental and economic issues have been added when the need for new knowledge in these fields became clear. The time may have come for further renewal of several project scopes, in particular with respect to industry (for example, an increased course activity for industry staff) and regional needs (for example, assistance for research capacity building in Mozambique).

**Project Sustainability.** In spite of the successful research capacity building process and the presence of several other foreign donors on Campus, the four projects would suffer severely if the support through SAREC were withdrawn in the near future, especially with the present lack of local research funding. The support from SAREC is almost unique in its flexibility: Funds may be used for those activities which are most needed at any time; most other donors require adherence to narrowly defined guidelines for project activities.

Although increased cooperation with industry may help provide some additional funding for the projects, it is unlikely to satisfy the main financial needs of the projects (with the possible exception of the Chromite Mining Project), at least as long as these continue with their main missions of producing research results and providing training on the basis of academic research. It is more likely that substantial income may be generated through the provision of assistance to capacity building elsewhere in the country and region.

Also the general university support is critical. Without the support for journal subscriptions in the Main Library, a severe gap in the holdings would result. A planned, extensive internet service in the Library would not yet be able to replace the journals, although this situation should be carefully monitored.

**Main Recommendations.** In addition to a number of specific recommendations for each individual project, the Evaluation Team recommends in particular:

- that SAREC continues its support for all four projects, but at different levels, as well as its general support for the University of Zimbabwe,
- that part of the support specifically be aimed at the creation of incentives for present and future project participants, thereby strengthening the potential for recruitment of new talent. This may include the introduction of postdoctoral schemes for which all four projects are ready,
- that the project areas are allowed to develop within each host department when such opportunities appear and that industrial contacts are strengthened, for example through an intensified course activity for industry
- that the role of the Faculty of Science is strengthened, for example in connection with outside funding of research in the Faculty, and that SAREC discusses the possibility of new projects with the Faculty. Among the potential hosts for new projects is the Chemistry Department, which has extensive, modern instrumentation and is in a key position in regard to many important applications in the country, but lacks funds and manpower to take full advantage of this situation,
- that incentives are provided for increased local cooperation, both between the four projects and in general within the Science Faculty, for example with respect to the earth sciences,
- that the projects in return for renewed funding gradually are given specific tasks in connection with the build-up of research capacity elsewhere, both within industry and higher education in Zimbabwe and, increasingly, elsewhere in the Southern Africa region, and
- that SAREC introduce standardized reporting procedures for individual projects, with a high emphasis on project outputs.

## 2. Background

### 2.1 Research Capacity Building in the Third World

**The Need for Increased Research Capacity.** The most important difference between industrialized and developing countries is the ability of the former to develop, select, modify, apply, and disseminate science based knowledge for economic gain. The recent fast technological development in industry, agriculture, health, and environmental management has made the efficient use of scientific knowledge even more important. Although such knowledge is often internationally available at little cost, many developing countries are unable to take advantage of these opportunities because of a severe shortage of research trained manpower and of competent science and technology (S&T) institutions.

Zimbabwe has in this respect been in a relatively fortunate situation compared with most of Africa, for example with respect to agriculture and mining as well as the environmental field; in spite of a shortage of research trained manpower, knowledge created within global research networks has in practice become available in Zimbabwe without much delay.

**Import of S&T Manpower.** Some industrialized countries also face a manpower problem in S&T, in particular the United States. However, while rich countries are often able to import the needed manpower, especially in the form of bright young students or graduates from developing countries, Third World countries do not have such possibilities except for the large amounts of short term technical assistance which traditionally has been provided by donor agencies and development banks (Thulstrup, Fekadu, and Negewo, 1996).

**Foreign Training.** For Third World countries, the most obvious strategy is therefore to train their own nationals in the fields of manpower needs. A common strategy has been to provide overseas study opportunities in industrialized countries for talented students from the Third World. This strategy has not always been successful: Often students have specialized in less relevant fields or even worse, they have not returned home after graduation because of job offers from the industrialized countries. Some low income countries in Africa have been seriously damaged by such a brain drain; in the case of Zimbabwe these problems exist but are less serious than in many other African countries (Zvaunya, 1996).

**Different Levels of Research Capacity.** Research capacity exists at different levels. Olsson (1996) refers to "excellence in research" and "qualified research", which must be based on capacity development (research training, research facilities) and research infrastructure (recruitment for research, research information systems, research management). In a recent evaluation of research capacity building in Ethiopia (Thulstrup, Fekadu and Negewo, 1996) a distinction was made between research capacity at the first level (ability to carry out good research in cooperation with others), capacity at the second level (ability to carry out good research independently) and national research capacity (the ability in a country to prioritize, support, evaluate, and sustain research). Many research capacity building programs stop at the first level; in all of the four SAREC supported projects in Zimbabwe included in this study, the second level is reached. However, the capacity established at the national level may be in danger in Zimbabwe because of the present financial conditions and extensive dependence on foreign research funds

(see below). If the national research capacity is insufficient, it may be difficult to sustain capacities created in particular research fields. Locally, the sustainability of individual research activities may be improved by linking them with support at the departmental, faculty or university levels (Olsson, 1992).

**Support for S&T Capacity Building Efforts.** Most bilateral donors devote a very small share of their total aid for developing countries on support for scientific research and higher education. On the average these fields only receive a few percent of the total development assistance (IDRC, 1991, Eisemon and Kourouma, 1992); globally, this corresponds roughly to USD two billion annually. The detailed priorities for use of the aid are often strictly defined by the donor; sometimes it is overlooked that individual aid components only can be efficient if other key components are present: Provision of foreign training without facilities at home that makes it possible to take advantage of the training, provision of equipment without buildings to use it in, or provision of research facilities without incentives for active research are just a few examples of incomplete attempts of research capacity building. The key components for research capacity building are (Thulstrup, 1995):

- Training, especially of university staff, including researchers, teachers, technicians, librarians, and managers in **all** relevant aspects of university education and research,
- provision of buildings for teaching activities, research, libraries, administration, and possibly for housing of staff and students,
- provision of teaching facilities, including class-rooms, teaching equipment, teaching laboratories, etc.,
- provision of research equipment, computers and service facilities for research and teaching equipment,
- funds for operation and maintenance - it is generally considered important that these are provided by local sources,
- provision of textbooks, research journals, access to data bases and other communication channels - in recent years electronic communication (faximile, electronic mail) has become an extremely valuable tool for international communication among researchers,
- on a national level, support for development of professional societies, subject specific research journals, and communication channels between universities and users of knowledge (i.e. industry, extension services, health workers, schools, etc.),
- access for university researchers and educators to international communities in the relevant fields;
- incentive systems at all levels (at universities, faculties, departments, and for individual administrative staff, teachers, researchers, and students) which ensure that facilities and working time are used in the most productive fashion - important ingredients in such incentive systems are well designed and fair promotion rules and salaries, which enable staff to be fully committed, and

- monitoring and evaluation systems, not only for the build-up phase, but more importantly for the productive situation that is supposed to follow the initial investments.

If some of these key components are not present at the beginning of the project or are provided simultaneously by others, they must be included as an integral part of the project. It is a characteristic quality of the research support provided through SAREC that all the necessary components are covered, according to the needs in particular circumstances.

**North-South Cooperation.** Capacity building within scientific research and higher education in developing countries is known to be difficult, partly because governments in Third World countries must satisfy many, more basic and seemingly more urgent needs. In spite of a potentially high economic rate of return for investments in higher education and research, the benefits usually appear only after several years, while other investments produce outcomes which are more immediate and are more visible.

**Research Partnerships** between individual groups in the North and the South are increasingly seen as the most efficient model for capacity building in the South (Gaillard and Thulstrup, 1994; Olsson, 1995), but are not without their problems. In particular, a frequent initial lack of capacity in the South may lead to an asymmetry in the cooperation, with the more experienced researchers located in the North and the less experienced in the South. This situation makes it tempting to divide tasks between the partners according to their experience, which may prevent partners from the South from acquiring a complete research capability. These risks are often overlooked by project partners who forget that the main task is capacity building, not production of research results (Thulstrup, Fekadu, and Negewo, 1996). In the SAREC funded projects in Zimbabwe, such problems seem to be minor.

Part of the training activities in a North-South partnership often take place in the North. It is particularly important that this does not seriously reduce the contact of the trainee with the home base and that the training is designed with future tasks at home in mind (Thulstrup, 1994). Nor should foreign training lead to an excessive weakening of the home institution, not even for a short period. This has sometimes been overlooked; at the Faculty of Economics at the University of Mozambique, generous support for staff training and other opportunities led to an almost complete depopulation of the Faculty, with only one full time teacher left (Olsson, 1992). Sometimes donor organizations and development banks have failed to prevent such unfortunate outcomes, but problems of this kind seem insignificant in the SAREC sponsored cooperative projects between Sweden and Zimbabwe.

**Sandwich Programs.** Much assistance for capacity building in scientific research and higher education in developing countries is still dominated by provision of foreign training - for example 69% of the support for higher education in Cameroon and 72% in Nigeria (Eisemon and Kourouma, 1992). Especially because of the risk of a brain drain in traditional overseas research training programs, other models must be considered, for example "sandwich" programs in which the students spend a substantial amount of their studies carrying out research in the home institution. Most SAREC sponsored basic science research training programs in Zimbabwe, are based on the sandwich model, while other Zimbabwean programs are exclusively located in Zimbabwe, thereby reducing the risk of brain drain.

**Experience from North-South Capacity Building Projects.** In general, research capacity building in the Third World is likely to require support over long periods, typically 10-15 years (Danida, 1992). During this period, long-term partnerships with researchers in industrialized countries may be highly efficient (Gaillard and Thulstrup, 1994). However, it is an important condition that suitable partners, with a common interest for capacity building, not only for production of research results, can be identified in both countries. SAREC is one of the relatively few donor organizations that consistently has used the North-South cooperative model for higher education and research capacity building. Based on the experience gained during the many years of SAREC support of higher education, research and research training in the Third World, Bhagavan (1992) lists a number of key recommendations for cooperative projects between institutions in developing and industrialized countries:

- Each cooperating group should include a substantial number of researchers (the cooperation should be "institutionalized"),
- the partners should meet regularly to review ongoing work and plan future activities,
- transparency in all budget matters should be ensured,
- research papers should be written jointly - e.g. names from both cooperating research groups should appear on the research publications, and
- project managers on both sides should be senior scientists in central positions in their respective institutions.

Similar criteria for constructive cooperation seem to be valid in other programs (Gaillard and Thulstrup, 1994) and are, for example, also listed in the evaluation report for the similar Danish (Danida) funded ENRECA program (Danida, 1992), together with six additional recommendations:

- Capacity building must include all aspects of the work to be done (not only the research itself, but also how to invest in and manage research facilities, and disseminate research results),
- no single capacity building project is able to secure development on its own, but must be designed in coordination with related activities in the country,
- research training is an important part of capacity building towards sustainability. In order to increase the commitment, it should, whenever possible, be part of formal degree programs,
- the remuneration of local staff involved must be sufficient to ensure a full time commitment,
- efficient and fast communication channels, such as faximile and electronic mail, must be available to secure efficient interaction between partners, and

- project monitoring and evaluation are important, both as learning processes and as a way of providing guidance and incentives to project participants. Monitoring should emphasize project outputs.

Three further points dealing with university cooperation may be added to these (Olsson, 1996):

- A limited number of institutions should be targeted,
- national universities are pivotal institutions in capacity building,
- a basis for research must be created before postgraduate programs are established, and this is only possible with highly selective use of resources.

## 2.2 The Role of SAREC

**SAREC** was founded in 1975 with the task of providing support for relevant research activities of primary interest for developing countries. In 1995, SAREC was merged with SIDA and some other Swedish aid organizations into a new organization, Sida. SAREC was originally established because it was felt that research may promote development effectively, in particular research which is carried out, managed, and prioritized by the developing countries. Research capacity building in the Third World was given the highest priority, but also Swedish institutions were encouraged to engage in research cooperation with institutions in the South. Whenever possible, the research support should promote the general cooperative development objectives of Sweden. The key activities supported by SAREC are:

- Assistance to developing countries in their own research capacity building which allows them to identify and solve important national problems,
- production of and transfer to developing countries of relevant research results in important areas, and
- promotion of scientific contacts and research cooperation between researchers in developing countries and researchers, both in Sweden and in other countries

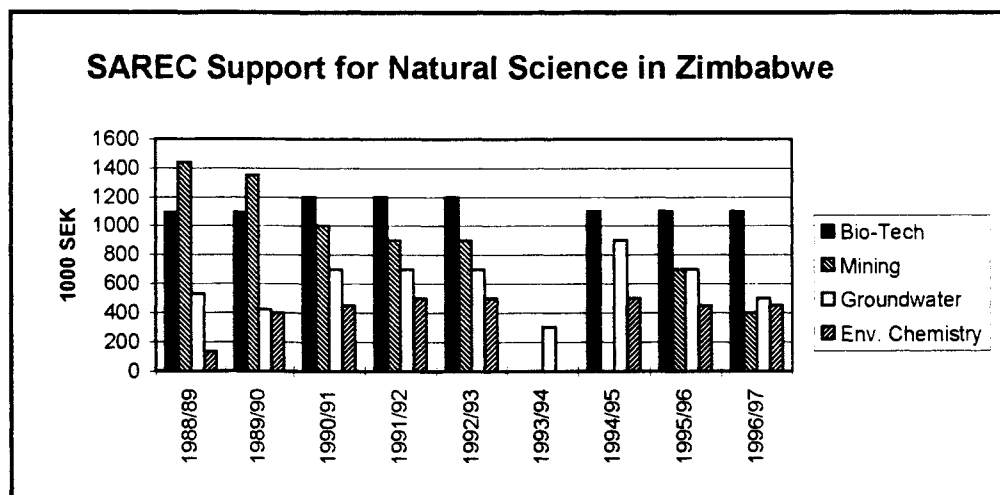
**Major SAREC Activities.** In order to promote research capacity building and utilization in developing countries, SAREC has established four interrelated research cooperation programs:

- The bilateral research cooperation program for very poor countries. Support is given to the basic training of researchers, provision of research infrastructure (laboratories, equipment, vehicles, books and periodicals, etc.), dissemination of research results, and the establishment of contacts between institutions and researchers in the developing countries and Sweden,
- the regional research program, which deals with regional institutions and issues. It encourages and facilitates regional research cooperation, and supports special projects in a regional context,
- the support program for international institutions and organizations engaged in research relevant for developing countries which provides assistance through international organizations, for example FAO, WHO, ILO, and IFS (the International Foundation for Science), and
- the support program for development research projects at Swedish institutions, with the purpose of enabling Swedish researchers to work on problems of importance for developing countries.

**SAREC Support for Research in Zimbabwe.** During the last eight years, SAREC has provided support for research projects and research management in Zimbabwe. The support has been given for activities in the following fields:

- Agriculture,
- natural science and technology,
- health,
- social science, and
- general activities at the University of Zimbabwe (for example the Main Library, a research council function, financial management capability)

**Figure 2.1**



**Natural Science and Technology.** The total SAREC support for Zimbabwe since 1988 amounts to SEK 71 million of which natural science and technology have received over one third, SEK 26 million. This support is presently provided to activities in four areas of particular strategic importance for the country:

- Protein Biochemistry,
- Chromite Mining and Ferrochrome Smelting,
- Groundwater Resources Development, and
- Environmental Chemistry.

Earlier also a special program for M.Sc. training in biotechnology was included; it received support between 1988 and 1990. A survey of the support provided to each of the four

projects over the years is given in Figure 2.1 above, while the exact amounts of support may be found in Table 2.1.

**Table 2.1**

**SAREC Budgets for Natural Science in Zimbabwe**

| Project Year | Protein Biotechnology | Biotechnology, M.Sc. Training | Chromite Mining | Groundwater Development | Environmental Chemistry |
|--------------|-----------------------|-------------------------------|-----------------|-------------------------|-------------------------|
| 1988/89      | 1 090 000             | 1 010 000                     | 1 440 000       | 530 000                 | 135 000                 |
| 1989/90      | 1 090 000             | 890 000                       | 1 350 000       | 420 000                 | 400 000                 |
| 1990/91      | 1 200 000             |                               | 1 000 000       | 700 000                 | 450 000                 |
| 1991/92      | 1 200 000             |                               | 900 000         | 700 000                 | 500 000                 |
| 1992/93      | 1 200 000             |                               | 900 000         | 700 000                 | 500 000                 |
| 1993/94      | 0                     |                               | 0               | 300 000                 | 0                       |
| 1994/95      | 1 100 000             |                               | 0               | 900 000                 | 500 000                 |
| 1995/96      | 1 100 000             |                               | 700 000         | 700 000                 | 450 000                 |
| 1996/97      | 1 100 000             |                               | 400 000         | 500 000                 | 450 000                 |
| Total        | 9 080 000             | 1 900 000 *                   | 6 690 000       | 5 450 000               | 3 385 000               |

\*The Biotechnology M.Sc. Training Project was closed in 1990 and has not been evaluated.

**Scientific Research and Training in Zimbabwe.** SAREC considers Zimbabwe a key country in the context of Southern African research. Outside South Africa, the University of Zimbabwe is the most advanced of the universities in the region, the infrastructure in Zimbabwe should be able to support research activities, and the country has a labor market in which research trained manpower is in high demand. Presently, a brain drain from the University of Zimbabwe to industry is more of a problem than a brain drain to industrialized countries. As a result of the present reduction in public sector expenditures (see below), university research in science based fields is usually no longer able to compete with conditions offered in the Zimbabwean private sector. As a result, many science departments have been unable to fill vacant positions and are presently severely understaffed, as described in Section 2.2 below. This is a very critical situation; depopulation of these university departments can hardly avoid having a negative effect on the number and quality of the young people receiving research training in the country. This, in turn, will further increase the pressure within the labor market.

## 2.3 Institutions Involved in SAREC Natural Science Projects

**Recent Financial Conditions in Zimbabwe.** After independence in 1980 Zimbabwe introduced a series of socialist reforms, which were not changed much until the 1990s, when a gradual replacement by more pragmatic policies took place. In 1991, Zimbabwe started an economic structural adjustment process designed by the International Monetary Fund, and consisting of cutbacks in public expenditures, privatizations, devaluation and liberalization of currency and trade. The adjustment became particularly difficult because of a severe drought in the early 1990s.

Nevertheless, and contrary to the situation elsewhere in Africa, this period did not lead to serious political instability in Zimbabwe, but hardships have been felt in many sectors, including public higher education and research, as discussed below. In spite of hopes for economic progress in the coming years, high unemployment, a very high number of AIDS victims in the population, and a fast population growth (over 3% annually) make it very doubtful that the conditions for research and higher education within the public sector will improve significantly in the near future.

### 2.3.1 The University of Zimbabwe.

All four natural science projects included in the present evaluation are carried out on the campus of University of Zimbabwe. The foundation stone of the present campus was laid in 1953. Two years later a Royal Charter was granted to the "University College of Rhodesia and Nyasaland", linked to the University of London, and full-time operations started in 1957. Courses could be taken in only Arts and Sciences, leading to a one year "Postgraduate Certificate in Education". The College became a university under revised statutes in 1970 and was renamed the University of Zimbabwe in 1980. The Charter was replaced by an Act of the Zimbabwe Parliament in 1982, which was further amended in 1990.

Today, the university has 10 faculties, 72 departments, over 1 100 full- and part time lecturers, 3 000 support staff and well over 13 000 students, 8 500 full-time and 5 000 distance students. The present annual budget is around ZWD 320 million (SEK 220 million), of which over 80% is spent on salaries. The University is located 6 kms north of the center of Harare on a large campus of almost 200 hectares, donated by the city of Harare. It has a wide range of facilities for both academic pursuits and recreation. A Health Clinic and dormitory rooms for 3 500 students are also available on campus. Due both to general cutbacks in the public sector and competition for funding with the new universities (see below) the University of Zimbabwe is presently experiencing severe financial limitations.

The power structure within the university is decentralized as in some Nordic countries. Deans and Department Chairpersons are given relatively little influence, while individual project managers have considerable power. This provides a feeling of responsibility which is an important motivating factor and it keeps the level of bureaucracy low, but the system also makes it difficult to coordinate actions and take extensive initiatives.

**Research Funding.** The University Research Board has earlier been the main source of funding for research projects carried out by the academic staff in the University. It used to be able to spend 5% of the University recurrent budget; now this percentage has dropped below 2% (ZWD 5 million - SEK 3.5 million - for 1 300 research staff). On the average, a research

active professor may expect to receive ZWD 5-10 000 (SEK 4-7 000) per year for research projects. It is therefore not surprising that active research at the University of Zimbabwe today is heavily dependent on foreign sources, as illustrated by many examples in the following.

**Financial Services in the University.** The problems within the financial management systems on Campus have been known for years but they continue, in spite of direct SAREC support. Numerous complaints were heard on Campus about inaccurate and slow services in the important Bursar's Office. A major reason for the problems is that university salaries for accountants are unable to compete with those paid in the private sector. Apart from these problems, the university handling of foreign research support seems reasonable. No overhead is charged on such grants; however, irrespective of how long the funds remain in the university accounts no interest accrues. In a country with an inflation and annual interest rate of over 20 %, the interest earnings of the University may, on average, correspond to an overhead of around 10% of the grant.

**The Faculty of Science** (including the Institute of Mining Research, IMR, see below) has ten departments with close to 150 senior academic faculty members (full and associate professors, senior lecturers, lecturers, and similar staff in IMR). Additional staff include technicians and teaching assistants. The largest departments outside IMR are those for Biology and Chemistry. The Faculty and Departments are generally well managed and research active, also under the present financial constraints. Quality control of the research based teaching has traditionally involved the use of highly qualified external examiners; this system is presently in danger because of the limited funds available, especially for examiner travel costs.

**The Main Library** at the University of Zimbabwe contains over 500 000 books and periodicals and has traditionally been considered among the best on the African continent. In recent years severe cutbacks have taken place in the university funding for books and journals. Most research journal subscriptions (a total of around 350) are today paid for through a special SAREC grant. The total budget for new science books is typically around ZWD 50 000 (SEK 35 000) per year. An automatization of the library with South African software is presently in progress, supported by a ZWD 1.5 million grant from the local Anglo American Corporation. Most importantly, this project will provide wider access to internet services; however, a dedicated telephone line for this purpose is still missing. Presently, small departmental libraries are growing elsewhere on the Campus without any involvement of the main library. Some of these offer good, including computerized, services, also to outside users.

**Other Universities.** The second public university in Zimbabwe, the National University of Science and Technology, is located at Bulawayo, 500 kms Southwest of Harare. A major building is presently under construction. The University was established in 1990 and is primarily conducting four year sandwich courses which include one year in industry. Additional new universities have, with encouragement from the Government, been formed by Church related organisations, for example the Africa University, established by the Methodist Church, which is particularly strong in agricultural sciences. Provision of research trained manpower for these new universities will be a major task for the University of Zimbabwe in the coming decade.

**Examples of Related Non-University Research Centers.** In addition to the universities other centres of research are active in the country, for example the Scientific and Industrial Research and Development Centre (SIRDC) at Hatcliffe, outside Harare. Its Director General was previously Head of the Department of Biochemistry at the University of Zimbabwe. Although SIRDC does not at present have biochemistry laboratories some of their biochemists are being trained overseas. The Kutsaga Research Centre of the Tobacco Research Board has well equipped laboratories in which the Biotechnology Department plans to study a wide variety of transgenic plants. Also the Mining industry has considerable research activities. Within agriculture, the Agricultural Research and Specialist Services Laboratories are active, and the Blair Research Centre for Public Health and Preventative Medicine carries out health related research. The departments receiving SAREC support are at present a main source of personnel for these research institutes and related industrial research.

**Degree Programmes at the University of Zimbabwe.** The degree system at the University of Zimbabwe can be summarized as follows:

- **B.Sc. (General):** A three-year program in which students read two subjects, e.g. chemistry and physics. At the end of the second year, the most able students are selected for an honours degree, i.e. **B.Sc. (Honors)** for which they pursue studies in a single subject, e.g. chemistry, during the final year. Modest government support is available for students at this level. Undergraduate students are recruited from the whole of Zimbabwe; it is considered to be very difficult to obtain a place at the University. Selection of students is based on the results of Cambridge A levels examinations. The most popular subjects are medicine, engineering, pharmacy, veterinary science, followed by the basic natural sciences. Among the latter, chemistry is the most popular and thus generally attracts the best students.
- **M.Sc. and M.Phil.** Two types of higher degree programs are offered at the next level, namely the **M.Sc.** (duration one additional year after the B. Sc.), which consists of courses and a final project which is presented both as a paper and orally in seminar form, and the **M.Phil.** which is a research degree of two years duration, without formal courses. In addition to the supervisor, external and internal examiners pass judgement on the theses. Both types of program are very popular; for example in chemistry, only about 10 among the 40 to 50 applicants per year for M.Sc. enrolment are selected on the basis of a test. The minimum criterion for enrolment for a M.Phil. degree is high - Class II(i) at the B. Sc. (Hons.) level. There is no government support available for students at this level, and students are therefore reliant on industrial or other external (for example SAREC or UNDP) grants.
- The doctorate, **D.Phil.**, is wholly a research degree, without formal courses. The duration is a minimum of three years, but usually the studies take well over four years of full-time work. Thus a successful full-time M.Phil. graduate can obtain a D.Phil. after one further year of research. Since studies are often pursued part-time, it may take a candidate six to eight years to obtain a doctorate.

**Recruitment Problems.** A severe problem is that it is difficult to recruit the best students to science based research degree programs owing to competition from industry. Better economic conditions during the studies would be needed in order to attract the most able

students. It is estimated that in order to get the best students, a stipend of approximately 8000 ZWD/month for each student would be required. This is at the moment unrealistic. In a way, the shortage of staff goes back to the independence in 1980, when well over half of the university staff left.

**The Bonding Scheme.** Research staff development within the degree programs is linked to a bonding scheme whereby a staff development research fellow, in return for the leave granted for their studies, has an obligation to work as a teacher (lecturer) at the University of Zimbabwe for a stipulated length of time after completion of the training. For instance, a graduate student, having received SAREC support to spend one final year in Sweden in order to work on a Swedish M.Sc., would after graduation be expected to work as a lecturer at the University of Zimbabwe for two years. The bonding system is considered to be better than repaying the educational grants as it motivates the students to return to Zimbabwe and reduces the risk of them leaving the University of Zimbabwe or the country.

### 2.3.2 The Department of Biochemistry.

**Teaching.** Although the Department is part of the Faculty of Science it provides teaching services for both science and medical students. The latter can participate in an intercalated year to gain a B.Sc. before going on to their clinical studies. The M.Sc. program runs over two years divided into one year of course activities and one year of project work. There are also active M. Phil. and D. Phil. programs which usually requires at least three and four years, respectively, of studies.

**The Staff.** There are 14 research staff members in the Department. The Chairmanship rotates between these with a three year term. Among the main research interests outside the SAREC supported project (see later) are protein structure, drug metabolism, particularly the role of cytochrome P450, environmental matters, plant virology, and immunology. As described above, the university support for scholarships has decreased in recent years so that postgraduate stipends now depend on overseas grants (Section 3.1). The Teaching Assistants are supported by the university and can engage in part-time study for a higher degree.

**Research Funding.** As discussed above, the University Research Board has recently not been able to provide any significant support for research projects. Presently virtually all research activities in the Department depend on grants from overseas. In addition to the SAREC grants (see later), support has been provided by several agencies, including International Seminars in Physics and Chemistry (IPCS, based in Uppsala), the International Foundation for Science (IFS), the International Atomic Energy Agency (IEA), the French Government (Cupertino with Strasbourg), and the McKnight Foundation (USA). The M.Sc. program is supported by the Netherlands Government through the Free University of Amsterdam. A further promise of support for research on lectins and of assistance for M.Sc. students has recently been given by the Belgian Government.

### 2.3.3 The Institute of Mining Research Research (IMR)

The Institute of Mining Research Research (IMR) was established in 1969 by the Ministry of Mines in order to provide applied research in support of the mining and metallurgical industries in Zimbabwe. Although it is part of the Faculty of Science, its members are not normally required to participate in the teaching of undergraduates; it is, in principle, a full time research institution. Located near several relevant university departments (geology, chemistry, physics, engineering, economics) it has developed its own considerable, interdisciplinary research capability, including a strong chemical analysis facility, which alone produces over 180 000 analyses per year. The services of IMR fall within the following subjects:

- Analytical chemistry,
- applied mineralogy,
- coal analysis,
- exploration geochemistry,
- mineral economics,
- mineral processing,
- mining geology,
- pyrometallurgy, and
- rock mechanics

**Laboratory and other Technical Facilities.** The IMR has a considerable amount of modern equipment and other facilities, including instrumentation for emission spectroscopy, such as X-ray fluorescence, scanning electron microscopy, X-ray diffraction, optical microscopy, and image analysis. The IMR has a fully computerized library with relevant databases. As an important addition to be made in late 1996, a SAREC sponsored database of Zimbabwean mines will be installed at IMR by the Raw Materials Group of Stockholm. A Zimbabwean graduate student, working on a degree at Luleå Technical University in Sweden has participated in the work and has been trained in the use of the database.

**Research.** In contrast to the surrounding departments, the research results from IMR are usually published in the form of reports for specific purposes, sometimes with limited availability, and rarely as ordinary scientific publications. Only a few out of a hundred research reports were in the form of publications in international journals (see Annex 4). Beneficiaries of the research are not only government institutions and Zimbabwean industry, but also other countries in the region. IMR has also successfully organized UNESCO sponsored training courses in Mining Geology for African students. Much of the research is concentrated on the Great Dyke, which contains the world's largest resource of high-grade chromite, the second largest resource of platinum, palladium and rhodium as well as

significant amounts of nickel. Other mining areas in Zimbabwe contain deposits of gold, copper, nickel, asbestos, iron ore, etc.

**Staffing.** The basic IMR funding is obtained from the Ministry of Mines, not from the Ministry of Education. The IMR is a multidisciplinary institute with a staff of approximately 40, of which 14 hold research posts. Shortage of research staff and technicians is considered to be the main problem. For example, planned, urgent work on a minerals database has recently been postponed and mineral processing work is currently dormant at IMR. There is severe competition with industry for competent people in spite of the fact that the salaries paid by the Ministry of Mines are higher than salaries for comparable staff at the university.

**Student Salaries.** Students from the Department of Metallurgy are employed during vacations as temporary technical assistants by the IMR. Typical salaries for a second or thirdyear student are around 250 ZWD (SEK 150) per week. A graduate student at the IMR working as a research assistant would receive between 5 000 and 7 000 ZWD (SEK 3 500 to 5 000) per month. During study visits abroad under a SAREC sponsored project, graduate students receive scholarships at the appropriate level for the relevant country.

**Technicians.** Technicians at the University of Zimbabwe are currently relatively well paid and a technician can earn as much, if not more, than a lecturer. However, academic staff now have hopes of a 20% increase in salary and will catch up with the technicians. Few technicians leave the IMR for industry, both because of the reasonably competitive salaries and the greater degree of freedom they experience at IMR.

## 2.3.4 The Geology Department

The Geology Department at the University of Zimbabwe was founded in 1960 with a single academic employee. Presently there are thirteen teaching and nine technical staff members. The Department offers B.Sc. and B.Sc. Honors degrees, M. Phil. and D. Phil. The two undergraduate programs typically attract fifty (B.Sc.) and ten (B.Sc. Honors) students per year (Nuffic, 1996). The Geology Department also offers teaching services for a number of relevant engineering and agriculture departments at the University.

**Mineral Exploration.** At the beginning of 1996 an M.Sc. program in Exploration Geology was started in order to satisfy a strong demand for high level training in this field. This is part of a long term strategy of the Geology Department, which intends to become a center of excellence with respect to mineral exploration. Several students from other African countries are following the M.Sc. program in the Department. In addition, five D.Phil. and five M.Phil. students are currently enrolled. As a result of the high demand for research training, several Zimbabweans work on their Ph.D. in geology outside the country, primarily at South African universities.

**Cooperation within the University of Zimbabwe.** There is some cooperation with the SAREC supported group for Environmental Chemistry in the Chemistry Department. Although the Department of Geology receives some support from the Ministry of Mines there are only informal contacts with the Institute of Mining Research (IMR), primarily through the Earth Sciences Research Seminar Series and a limited joint use of

instrumentation. The Department of Geology tried to donate their microprobe (see below) to the IMR, but the IMR did not want to accept it.

**Creation of a "Research School for Mineral Resources".** Plans for creation of a larger "Earth Sciences Center" or a "Faculty of Mining" at the University of Zimbabwe have recently failed, even though the arguments in favor of such a concentration are strong, given the present situation. The problem encountered was primarily that existing departments would lose staff (the Physics Department, for example, would lose half its staff if geophysics were removed) in a situation where shortage of staff is their most serious problem, as discussed above. Earlier this year, a Nuffic mission looking at mining research in Zimbabwe (Nuffic, 1996) recommended that a Research School for Mineral Resources be created at the University of Zimbabwe. With the proposed looser structure in the Research School this might reduce the problems in connection with the removal of staff from existing departments. Staff for the Research School would be found at IMR, and the Departments of Geology, Physics, Mining Engineering, Metallurgy, Law, and Commerce.

There is little doubt that such a Research School would be able to provide training, research, and instrumentation services (the latter especially at IMR) in high demand within the mining industry. It is worth noting that at the new National University for Science and Technology in Bulawayo a similar construction, the Zimbabwe School of Mines (ZSM), has already been established. However, it must be ensured that the creation of a Research School does not reduce the productivity of the departments involved with respect to the regular teaching, which is still the main, and most important task, of the departments outside IMR.

**Facilities.** The Geology Department has considerable laboratory facilities. They have been called: "the best north of Limpopo and south of Sahara" (Nuffic, 1996). The facilities include:

- Laboratories for wet chemistry, isotope geology, mineral separation, fluid inclusion, hydrogeology, and rock cutting and polishing,
- a photography laboratory for microphotographs
- equipment, which include facilities for atomic absorption spectroscopy, mass spectrometry, and ore microscopy,
- a geological museum, and
- a modest, specialized library

**Outside Support.** The Department has received considerable support from the Netherlands through Nuffic and the Free University of Amsterdam, NLG seven million (over SEK 25 million) over a three year period. About 25% of the grant was used to fund a Dutch advisor. Also the computer network in the Department has been financed by Nuffic.

**Technical Problems.** In addition to the facilities listed above, an electron microprobe is available, a gift from University of Leicester in 1989. However, even after extensive efforts within reconstruction of the instrument and technician training, both activities sponsored by Nuffic, the results obtained from the microprobe are still unsatisfactory (Nuffic, 1996).

Much of the microprobe work is today carried out in Cape Town where the facilities are both excellent and inexpensive. A USD 1.5 million EU donation of facilities for a Central Isotope Geochronology Laboratory (CIGLAB), which should serve the entire region, has had considerable technical difficulties both before and after the official opening in 1995. The costs of operation and maintenance of the planned CIGLAB would be extensive, and no clear plan for the financing was or is now in place. The EU has recently discontinued the support (Nuffic, 1996).

**Strong Research.** In spite of such problems, the research in the department is strong. It concentrates on the regional geology, which is rich and offers valuable material for high quality studies. The activity of research among the 13 academic staff members is high and the quality excellent. Publication in the best international journals is common; the performance is particularly impressive in view of the limited domestic research funding available. International contacts are good, and the Department receives numerous visitors from abroad; in addition to the high quality of the research staff at the University foreign visitors are attracted by the outstanding conditions for geological field research in Zimbabwe.

**Information Services.** The Department is now computerized; the Nuffic sponsored departmental computer network was installed in 1995, including a SAREC sponsored scanner. Electronic mail, but not yet Internet, is available through the University Computer Center. The library situation is acceptable. Although the Departmental library is small and the Main Library does not have a large holding of Geology books and journals, access to well equipped geology libraries may be found at nearby IMR and at the large mining companies. The SAREC sponsored remote sensing activities in the Institute are based on data from the receiving station in South Africa (another relevant receiving station is placed in Kenya).

## 2.3.5 The Chemistry Department

**The Chemistry Department** at the University of Zimbabwe is comprised of four Sections: Analytical, Physical, Inorganic and Organic Chemistry. The Department has recently received a Japanese donation of almost 7 million USD, enabling the purchase of modern equipment, especially for research but to some degree also for teaching. Nevertheless, the Department suffers from understaffing, both with respect to faculty and qualified technicians.

Of the 26 faculty positions at the department, only 18 are currently filled. One reason for this is that academic salaries are considerably lower than those offered by industry. Another general problem faced by the department, which has been enhanced by the large equipment grant, is insufficient funding for consumables and equipment maintenance.

**High Ambitions.** The Chemistry Department clearly identifies its mission as pursuing high quality research *per se*, but also as a basis for academic teaching. It recognises its obligation to train chemists for industry and to staff the new universities and colleges in Zimbabwe. To this end, it feels that it would benefit considerably if there were improved opportunities for faculty exchange on an international basis. Similarly, increased possibilities for student exchange at all levels would be highly welcome as a means of attracting even better graduate students. The following research activities are considered central:

- Research in **Analytical Chemistry** deals primarily with environmental problems, but also with the development of new analytical techniques. These projects are described in more detail in Section 3.4.
- Research in **Physical Chemistry** deals in particular with surface chemistry and catalysis. Also chemical and science education is included among the activities of the academic staff, in spite of the fact that only half (three out of six) of the faculty positions are presently filled in the Physical Chemistry Section.
- Research in **Inorganic Chemistry** concentrates on two areas: *Coordination Chemistry*, in particular, electronic properties of complexes of the lanthanides, organometallic complexes for catalysis, in collaboration with the organic section of the department, complexes of bioinorganic interest and *Intercalation Compounds*. Also the Inorganic Section is severely understaffed, only two of the five faculty positions are currently being occupied.
- Research in **Organic Chemistry** is carried out in two main areas: *Natural Product Chemistry*, namely the synthesis of natural products and the extraction of medicinal substances from plants, and *Organometallic Chemistry* directed towards *Catalysis*, in collaboration with the Inorganic Section.

**Departmental Computer Facilities.** Approximately 50% of the faculty and all the secretaries have access to PCs. Twelve PCs are available for students (both undergraduates and postgraduates). The department has access to e-mail facilities, but not to internet, and many have so far been hesitant to take advantage of the e-mail services offered (at a price) by the University Computer Center.

**Equipment.** The Japanese grant has been used for the purchase of a wealth of up-to-date equipment, which would be the envy of many chemistry departments in industrialized countries. The equipment includes a 400 MHz NMR spectrometer (both solution and solid-state), an FTIR/Raman spectrometer ( $5\text{--}50\,000\text{ cm}^{-1}$ ), HPLCs, and a GC coupled to a high resolution MS. Several instruments for teaching activities (especially for students in the final year of the Honours program), e.g. HPLC, UV-VIS and IR spectrophotometers and electrochemical instrumentation have also been purchased.

If these facilities are to be used to maximum advantage more intensive training of the departmental technicians in the running and maintenance of the extensive equipment (NMR, in particular) is necessary together with a stronger adherence by the University to its commitment to, as promised in connection with the grant, supply consumables for the active use of the equipment.

**Priorities of the Department.** Special emphasis is given to a strengthening of programs relevant for industry and public institutions in connection with the fast development of several sectors within the Zimbabwean economy. If this development is to be sustained, it will be necessary to gain a better understanding of the environmental problems which inevitably come with the development. This can only be achieved on the basis of a strong competence within Environmental Chemistry.

Other disciplines given high priority in the Department are Natural Product Chemistry and Synthetic Inorganic Chemistry, specifically the synthesis of new materials and of organometallic compounds of catalytic relevance. However, the need for strengthening (also by filling the numerous vacant positions) and further encouragement (provision of improved incentives for active research and new teaching initiatives) exist in all fields. It was stressed by the Department that possible new outside support for new programs should not be at the expense of the existing SAREC support for Environmental Chemistry.

The highest priority is given to improved financial aid and other incentives for graduate students since human resources for research comprise the limiting factor for scientific success of the Department. However, as discussed above, funding for consumables is also of high priority, as is further training for technicians. Not only the qualifications, but also the number of technicians is insufficient to run the newly acquired, highly advanced equipment to maximum advantage for the Department. The technicians in general have several, time consuming, duties and were typically required to divide their time between running research experiments, servicing equipment, and preparing laboratory exercises for undergraduate students. An improved efficiency might be obtained if the the work schedules allowed maximum use to be taken of the specialized expertise of individual technicians.

## 2.4 General Program Assessment

**High Quality, Active Research.** The four natural science projects supported by SAREC are all characterized by good and active research at an international level, as described in detail in Chapter 3 below. On the whole, the qualitative and quantitative levels of research reached are among the best in Africa, at least outside South Africa. The quality is so good that Swedish graduate students regularly are sent to some of the projects in Harare as a part of their training. In addition, and most importantly, the interest among young and talented students for pursuing careers in the four scientific fields is high. Unfortunately, the present conditions at the University of Zimbabwe do not make it possible to benefit fully from this positive situation.

**Research Outputs from the Projects.** In Table 2.1 above the input from SAREC for the four projects was given. Table 2.2 lists the number of research publications which the Zimbabwean project participants consider to be output from SAREC financed research activities; the publications are also listed in more detail in Annex 4. Although, as one might expect, the publication habits are different in different projects - with the more basic research activities producing mostly papers in international journals and the more applied producing more targeted reports - the numbers in Table 2.2, which have been provided by the projects, are characteristic for active and productive research environments.

**Table 2.2**

**Project Output: Publications**

| Publications  | International Journals | National Journals | Conference Proceedings | Other |
|---------------|------------------------|-------------------|------------------------|-------|
| Biotechnology | 24                     | 2                 | 30                     | 0     |
| Mining        | 2                      | 0                 | 3                      | 97    |
| Groundwater   | 4                      | 1                 | 9                      | 5     |
| Envir. Chem.  | 16                     | 2                 | 16                     | 0     |
| Total         | 46                     | 5                 | 58                     | 102   |

**Research Degrees.** Table 2.3 shows the number of research degrees resulting from the SAREC supported research (2 Ph.D.s and 34 M.Sc.s) and the number of research students presently working on such degrees (11 towards Ph.D.s and 20 towards M.Sc.s). The good quality of and high activity within the research projects is an indication of the solid quality of this training. But is the training also cost effective?

**Cost Effectiveness.** In an evaluation like the present it is difficult to produce quantitative cost-benefit data. One reason is that specific inputs are not linked to specific project outputs in a quantifiable way. For example, a given instrument, acquired with SAREC funds, is likely to help produce both formal and non-formal research training, technician training, research results, etc. Nevertheless, an estimate of cost effectiveness will be attempted.

**Table 2.3****Project Output: Research Training**

| Degree Programs | Ph.D./D.Phil. Completed | Ph.D./D.Phil. Enrolled | M.Sc./M.Phil. Completed | M.Sc./M.Phil. Enrolled |
|-----------------|-------------------------|------------------------|-------------------------|------------------------|
| Biotechnology   | 1                       | 4                      | 8                       | 5                      |
| Mining          | 1                       | 3                      | 1                       | 1                      |
| Groundwater     | 0                       | 3                      | 1                       | 1                      |
| Envir. Chem.    | 0                       | 1                      | 24                      | 13                     |
| Total           | 2                       | 11                     | 34                      | 20                     |

**The Costs of Research Training.** Based on experience from World Bank loan financed projects the typical expenses for developing countries in connection with provision of overseas research degrees to their nationals are USD 30 000 per year, corresponding to over SEK 400 000 for an M.Sc. and around SEK 900 000 for a Ph.D. (Thulstrup, Fekadu, and Negewo, 1996). These numbers may applied to the 2 completed Ph.D.s and 34 completed M.Sc.s from SAREC sponsored projects and, similarly, the costs of the 11 Ph.D. and 20 M.Sc. programs in progress estimated by assuming that about half of these study programs have been completed (corresponding to two and one year, respectively). This way, it can be concluded that the formal research training under SAREC sponsorship represents a value of about SEK 25 million, above the total amount provided by SAREC for the four natural science projects in Zimbabwe. In addition, the projects have produced other forms of degree training. For example, the Groundwater Project alone has produced three B.Sc Honors degrees, at a level not much below that of an M.Sc. degree elsewhere, and no less than eleven Swedish students have carried out their final project work in cooperation with the project in Zimbabwe.

**Other Project Outputs and Inputs.** In addition to the support for formal research degree training, SAREC funds have been used to provide many other benefits, e.g. non-degree research training, technician training, up-to-date equipment - now in operation on the campus of University of Zimbabwe or used for field work elsewhere in the country - and new knowledge of importance for the development of Zimbabwe. On the other hand, it must not be forgotten that the support from SAREC does not stand alone. Important contributions come from the University (particularly in the form of buildings and salaries) and in some cases also from other donors (for example, the extensive equipment sponsored by Japan may be used for training of the many M.Sc. students in environmental chemistry).

**Low Costs in Zimbabwe.** In spite of these other contributions, which are difficult to quantify in relation to specific training activities, there is little doubt about the high cost effectiveness of the sandwich model (or the purely Zimbabwean) research training under the sponsorship of SAREC. This has been discussed by Fernandes (1996) who concludes that the cost (in terms of fees) of an M.Sc. in exploration geology at the University of Zimbabwe is less than half that in South Africa and less than 15% of typical fees at universities in Europe, Australia, and North America. Foreign students in Harare are, however, charged above the actual costs, i.e. almost half the fees typical for industrialized countries.

**Cooperation with Sweden.** Three of the four projects studied have Swedish counterparts. There was in general considerable satisfaction on both sides with this cooperation, which leaves a large amount of financial management and other key responsibilities to the Zimbabwean partners, as discussed below. Visiting Swedish graduate students were common in the projects; these visits were considered useful by both sides.

The Environmental Chemistry project is performing very well without a formal Swedish partner, maybe at the highest cost effectiveness among the four projects (see, for example, Tables 2.1 to 2.3). In this connection it is interesting that the most cost effective among a large number of SAREC sponsored projects in Ethiopia was the one among them which was managed solely in Ethiopia (Thulstrup, Fekadu and Negewo, 1996). It must be stressed that this does not show that industrialized country partners are not useful, only that successful projects in some cases may be carried out without formal partners in the North. It is also common for all four projects that they are part of the informal international networks in their fields and cooperate with numerous partners outside those in Sweden.

**Cooperation on Campus.** The cooperation between the four, occasionally overlapping, projects and within the Science Faculty in general is not as strong in all respects as one might hope for. This will be further discussed in the following, particularly in connection with the earth sciences. Compared with other university systems, influence is spread out at the University of Zimbabwe (presumably based on a "democratic" ideal), and relatively little power belongs with department chairpersons and deans. This may make major cooperative initiatives difficult.

**Research Management.** An additional quality, which has developed during the lifetime of the three cooperative projects, is that much of the project management takes place in Zimbabwe. There is a relatively high degree of "symmetry" in the research cooperation between Zimbabwe and Sweden, although the capacity building still primarily takes place on the Zimbabwean side. The fact that all aspects of research management (decision on strategies, procurement of equipment, dissemination, etc.) is performed in Zimbabwe ensures that the capacity building takes place above the first level (Section 2.1). This is illustrated by the observation that when the Swedish counterpart in one of the projects was not easily available for an extended period, this did not cause any significant problems.

**Risks for the Research Quality and Productivity.** Two major shortages present an immediate risk for the future development of these positive research environments. One is a shortage of research funds for field work and for operation and maintenance of the extensive and high quality equipment in the four groups. The other is a shortage of qualified research manpower. Although it is a positive aspect in connection with training in science based fields at universities in Zimbabwe that the private sector has a high demand for research trained graduates (especially compared with the situation in many other African countries), this also creates severe problems. The universities must now compete with industry for recruitment of the best and brightest among the young talents. The present difficult financial situation, especially at the University of Zimbabwe, means that the universities are losing this competition at present. As described in the preceding section, numerous research positions are unfilled, many bright young graduates are prevented from pursuing careers within research because salaries for them are not available, and many worthwhile research projects are not carried out because of this shortage of staff and money.

A partial solution to these problems may be found in the establishment of post-doctoral positions under the projects. All of the projects would benefit considerably from employment of one or a few post-doctoral researchers; this would enhance the research output, would provide some relief to the project managers, and would be a significant incentive for academic careers in the four fields. At the moment University funds are not available for this purpose.

**Dependence on Foreign Research Funding.** It has also been illustrated by several examples how foreign support dominates in connection with the expenditures for research training, provision of research equipment, and the operation of research activities. For example, with the USD 8 million Japanese instrumentation grant, the Chemistry Department is now equipped with modern instrumentation at a high level, but it is unrealistic to believe that the University will be able to fulfill its commitment to cover the costs of operation and maintenance of this valuable resource.

**Modest Domestic Support.** According to information received from the four projects in Zimbabwe, the annual funding from the University of Zimbabwe is estimated to be around SEK one half million, mainly in the form of salaries (however, an exact separation of departmental support into project and non-project support is very difficult). Support is also provided by Zimbabwean sources outside the university, in particular by the Ministry of Mines, which provides funds for the IMR. These contributions are estimated to be about equal to the University support, for a total domestic support to the four projects of about SEK one million annually. This is below two percent of the Japanese instrumentation grant for the Chemistry Department (around SEK 50 million), below ten percent of the initial EU support for a geochronology laboratory in the Geology Department, and well below half of the annual SAREC support.

**Flexibility of SAREC Support.** Compared with most other foreign support, the assistance provided by SAREC is among the most useful because of the flexibility that is allowed in the management of the funds. Essentially all the key needs in connection with research capacity building listed in Section 2.1 can be supported. This quality of the SAREC support strategy was emphasized by several project participants, who also had appreciated the earlier presence of a SAREC regional representative in Harare.

**National Research Capacity.** As discussed above, the present cutbacks in public support present a risk to the foundation of research in Zimbabwe. In this connection, SAREC has attempted to support the national research capacity, for example through provision of subscriptions for over 300 research journals in the Main Library at the University of Zimbabwe and by the assistance given to a strengthening of the financial management at the University, unfortunately so far with limited success. Also support for a research council function at the University has been considered. In the future, this kind of support might be badly needed also at the faculty level both in order to preserve traditional incentives for active research and in order to make needed managerial reforms possible.

**Future Role of the Projects.** A considerable research capacity has been created in all four projects; still they are likely to become seriously weakened, or even collapse, if the SAREC support is withdrawn, since no other domestic or international funding source is likely to provide the flexible support needed. At the moment the main problems are the limited recruitment of new talent for the projects and the limited amount of efficient Cupertino between neighboring fields on

Campus, for example in the earth sciences. There is an indication that the extensive capability for provision of research training, which has been created in all four projects - even in the “non-teaching” IMR project - is not used to its full extent. This is wasteful, since the needs for research training are widespread, both within the country, especially at the new universities, and within the region, for example in Mozambique.

**Regional Centers for Research Training.** For many reasons, such as the high standards in the research activities, the geographical location, the good infrastructure in Zimbabwe, and the relatively low costs, the four projects should be well suited to take upon them wider obligations within the research training of graduate students. Zimbabwean participants in all four projects expressed a clear interest in playing a stronger regional role. There is, for example, little doubt that the four projects on the whole may be able to train graduate students from Mozambique and support their home base as well and at much lower costs than Swedish universities. This may be particularly relevant in connection with other SAREC and Sida sponsored projects in the region; one example is the Sida initiative for support to sustainable management of water resources in Southern Africa, which is presently under consideration (Granit and Johanssen, 1996).

## 3. Individual Projects

### 3.1 The Protein Biotechnology Project

The Protein Biotechnology project started in 1989. It was renewed in 1994 for a three year period which ends in June 1997. The support from SAREC has, in particular, enabled the group within the Department of Biochemistry to acquire capital pieces of equipment previously unavailable so that the project has had a favourable spillover effect on the rest of the Department. The average annual support has been about SEK one million. The Protein Biotechnology Project seems to fit well with the SAREC objectives in that research is being encouraged which should be relevant to the local industry, and postgraduate students are being trained who should be valuable both to local industry and the various research organisations which are in existence or being developed. The group co-operates with other researchers at the University, both within the Faculty of Science and in the Medical and Agricultural faculties.

**Other support.** In the initial phases of the SAREC project support for the financing of M.Sc. students was particularly valuable. More recently such support has primarily come from the Dutch Government through the Free University of Amsterdam. This arrangement seems to work well.

**Project Components.** The project deals with the identification and purification of enzymes and lectins, derived from indigenous plants, and microorganisms and their use in industrial and medical biotechnology. So far the focus of the project has been on basic research and technology development. The Protein Biotechnology project comprises three members of staff, four D.Phil. students, and several M.Phil. students. The research activities of the group may be divided in three sections:

- Polysaccharides from indigenous plants,
- lipids, membranes and bioorganic chemistry, and
- fermentation technology

There is considerable overlap between the projects in that they all involve the application of enzymes.

#### 3.1.1 Polysaccharides.

The following main results have been obtained:

- Mucilage isolated from *ruredzo* has been studied for the emulsification of fats and in a cross-linked form in the purification of pectin degrading enzymes.

- *Azanza garckeana* fruit produces a resinous substance during the hot dry months. The water binding properties are being studied. The use of the coloured substances that arise on heating the resin are being studied in a variety of foods.
- *Cordia abyssinica*, a medium sized tree, produces a fruit juice which is used as a glue. The potential properties of the mucilage are being studied as a binding agent.
- The polysaccharide degrading enzymes produced during the ripening of the fruit of *Strychnos* are being studied.

Presently, attempts are being made to introduce tissue culture techniques. Six postgraduate students are involved in the work on polysaccharides, two of whom are studying for a D.Phil. Seven publications arising from the work are listed together with a single patent.

### 3.1.2 Lipids, Membranes and Bioorganic Chemistry.

A wide range of problems in lipid biochemistry including the analysis of lipids for industry and research are being investigated. There is a particular interest in unusual plant lipids and plant seed lipases which complement the work on plant seed lectins. The investigation of microbial enzymes complement their study of biotransformations using plant lipases in organic media and biodegradations. Thermophilic microorganisms may be expected to produce thermostable lipases that could be used in industry. The following specific results have been obtained:

- A lipase has been isolated and characterised from rape seedlings. The lipase is active at water activities that are lower than those of microbial enzymes and hence may be useful for use in organic media. A lipase from *Vernonia galamensis* has been characterised. This seed produces the epoxy fatty acid, vernolic acid, which has potential uses in the polymer and coatings industry. The lipase has a strong specificity for the epoxy triglyceride trivernolin and the epoxy fatty acid. A chromatographic method has been devised for the purification of the epoxy triglyceride.
- Bacterial strains which produce lipases have been isolated from the Hot Springs in Chimanimani. The isolates produce the lipase when triglycerides or fatty acids are in the culture medium. A thermostable alkaline lipase has been identified.
- White rot fungi with lignin degrading capabilities are being studied. Ten fungal species obtained from the Chirinda forest are being investigated for ligninase production.
- Lectins from local plants of the *Leguminosae* and *Euphorbiaceae* families, are being characterised using the latex agglutination method to supplement the use of human red blood cells particularly for the lectin *Pterocarps angiolenses* which is specific for cord erythrocytes.

One postgraduate student has recently obtained his D.Phil. and has very recently been appointed to a permanent position. In addition, there are three students involved, including

one D.Phil. student. Five international publications are listed together with four others from related collaborative work.

### 3.1.3 The Fermentation Laboratory.

This is mainly concerned with the culture of microorganisms that produce biochemicals with a potential use in industry. There is also an interest in the role that microorganisms play in the traditional processing of food. Some main results are:

- Species of *Bacillus* have been isolated from hot springs in Binga, Chimanimani, and Chiredzi. These fast growing strains produce cellulose degrading enzymes. A bacterial strain that produces a thermostable protease has been isolated.
- The production of ethanol from sweet sorghum is being studied. The latter is more drought resistant than sugar cane. The cofermentation of juice from sweet sorghum and sorghum grain is being investigated. The effect of tannins and flavonoids on the production of ethanol is being studied. The use of sorghum grain in the production of fermented foods is also of interest.
- The changes that take place in the production of the traditional nonalcoholic beverage, masvusvu, which is made from millet malt is being investigated.

Six students, including a D.Phil. student, are involved in these research projects and eight publications are listed.

### 3.1.4 Opportunities and Problems

**Cooperation with Industry.** There are some limited industrial contacts. A part-time student is working with the Food & Industrial Research organisation and the Tobacco Research Board has supported an M.Sc. student. Also a brewing company has formerly supported an M.Sc. student whom they subsequently employed. Contributions to standards in agriculture have been made. Some analyses of oil seed lipids and paprika resin are being performed for the food industry and farmers. There is a particular interest among farmers in the possible replacement of their tobacco production by paprika and contact has been established with Unilever Limited.

A workshop has been planned for the Zimbabwe industry in order to raise interest for industrial applications of new technology, but firm plans for this do not seem to be in place yet. A cooperation with SIRDC on industrial applications has been considered, but there seems to be some concern that such collaboration would have to be a true partnership and that SIRDC would not be dominant. At the moment SIRDC has not yet established its own laboratories and has not yet trained any manpower. It is generally agreed among the parties involved that in any subsequent extension of the SAREC support, contacts with industry should be strengthened.

**Quality Standards and Problems in the Department.** The Department is among the best university departments of biochemistry in Africa outside South Africa. The theses either submitted or being prepared for the D.Phil. and M.Sc. were nicely produced and gave an impression of the good standard attained. The amount of apparatus in the Department is reasonable and most of it is kept in good working order. Also the buildings are well kept, but not very spacious (see later). However, some matters give rise for concern:

- **A Lack of Up to Date Literature.** The university library, is completely insufficient in terms of current biochemistry journals. Even journals like *Nature* and *Science* were not on display and had only recently been re-ordered. The Department has no library; even the texts on the shelves of the staff seemed old editions. While computers and E-mail were available, the Internet was not. A reasonable supply of even secondary journals is essential for the invigoration of the research. Improvements could be effected cheaply if the staff ordered journals at personal subscription rates. Although a CD-ROM of *Index medicus* and *Biological Abstracts* is available and the periods spent in Lund are invaluable in catching up with the literature, more paper journals are needed in the Department.
- **The Management of the Department.** As usual in the University the post as Chairman of the Department is endowed with little authority and the period of office (three years) is too short. The various research staff appear to work in groups with only limited cooperation between them. Perhaps this is inevitable when funds are at a premium but it is inefficient.
- **Lack of Space.** There is a severe lack of space for the staff. It is most unsatisfactory for senior staff to have to share an office with perhaps four others including students. This detracts from the cost effectiveness of the research effort.
- **Weak Molecular Biology Input.** The research reviewed often was lacking in the thrust that is brought by the methods of molecular biology. Ideally research should set out to tackle a problem and whatever methods are appropriate to the resolution of the problem should be applied. Today these methods must include molecular biology.

**Cooperation with Sweden.** In general the cooperation between Harare and Lund works well although it is not perfect. In international research cooperation through personal contacts at all levels is essential and these contacts are not completely without flaws. At present, the D. Phil. students arrive in Lund to spend six months learning techniques, mainly within protein purification. They may work as a group even though each is being supervised by a different member of staff in Harare. Efficiency could be improved if there were better cooperation between the D.Phil. supervisors in Harare and those who look after the students in Lund, although it must be stressed that the degree is awarded by the University of Zimbabwe. Clearly, the staff in Lund involved in the training of Zimbabwean students also have to look to their own promotion, but they should at least have an opportunity to visit Harare and see the environment on the spot. The duration of the visit to Lund, 6 months, must be regarded as the minimum period for a cost effective visit. On the purchasing arrangements for reagents and spare parts, the students said that in general they worked well but there were periods of frustration. This matter warrants constant attention to limit the bureaucracy.

A valuable addition to the project are the regular, semester-long visits at the Department by Swedish graduate students from Lund. They work under good laboratory conditions in Harare, receive valuable guidance from the local academic staff, and help ensure a high degree of activity in the Department; their presence is welcomed by the Zimbabwean hosts. On a broader level, these visits help increase the knowledge base in Sweden about science in Zimbabwe in particular and in the Third World in general.

**The Cost Effectiveness of the Project.** The expenditure in Lund for the Protein Project is under one third of the total outlay, below the number typical for other SAREC projects. The allocation of funds under various items in the latest budget (1996/97) seems reasonable. The situation whereby the Swedish university accrues some income for their staff costs is in marked contrast to that with British Council Links where only travel expenses are paid, which is a disadvantage in an "accountant-led society". The ability of the Harare staff to travel overseas annually is particularly valuable.

A list of publications is given in Annex 4. The publication of scientific papers from departments in developing countries presents many difficulties (Thulstrup, 1994). It is to the credit of the project participants that they have been invited to contribute to a publication like *Methods in Enzymology*.

**Sustainability.** Consideration has to be given to how long an organisation like SAREC should continue its aid. Clearly, such aid should not fully substitute for the supply of local funds. It may be that the present freeze is temporary and stems from the drastic drought of three years ago, but reassurance on this matter was not available. SAREC has done much to assist the Department to create a sound basis for teaching and research; now the biotechnology group should be ready to collaborate with industry and take up other assignments, also at a regional level, thereby justifying its existence in economic terms. Considerable international experience today exists regarding collaboration between academia and industry and, as mentioned above, several industrial links already exist. Furthermore, the need for research training in the region is high, both in connection with the establishment of new universities in Zimbabwe and in the neighboring countries. The group in Harare should be able to contribute considerably in this connection.

## 3.2 The Chromite Mining and Ferrochrome Smelting Project

The project "Development of Chromite Mining and Ferrochrome Smelting in Zimbabwe" started in the late 1980s as a cooperative project between the Institute for Mining Research (IMR) at the University of Zimbabwe and researchers at the Royal Institute of Technology (KTH) in Stockholm and other Swedish researchers. The goal was to carry out research and research training which would strengthen the productive capacity of the economically very important chromite mining and processing, including production of high quality ferrochromium alloys in Zimbabwe. Today the research includes both natural science, environmental geology, and mineral economics components, the latter in cooperation with Luleå Technical University in Sweden. The economic components in IMR are primarily the result of the SAREC financed cooperation. In 1994, an increased awareness of the environmental consequences of the present mining activities including the widespread small scale gold panning in the country led to inclusion of a new SAREC financed research component dealing with environmental assessments of these activities. The emphasis on "sandwich" model training of IMR staff was also increased in this second phase. In recent years, the chromite aspects of the project have been less dominant in the actual work, which today, in addition to the new economic and environmental aspects in the project, aims at a fairly broad upgrading of the research at IMR. For this reason it would seem proper to rename the project if it is decided to renew the funding after 1997.

### 3.2.1 Project Input

The projects may be divided into the following four main activities:

1. **Mineralogical and Geological Research** which is concentrated in the Great Dyke Area, containing the largest high grade chromium reserves in the World.
2. **Metallurgical Research** carried out on ferrochromium and stainless steel.
3. **Mineral Economics** including establishment of a minerals database.
4. **Environmental Geology** including both geochemical and geomechanical aspects.

**Foreign Support - Project Input.** The project has on the average received close to SEK 750 000 per year in SAREC support; the largest amounts were paid during the first years, while the support has dropped to SEK 400 000 for the present year (1996/97), primarily for staff training. In addition to upgrading of staff the local project management considers it important that SAREC funds have made it possible to acquire some important improvements of equipment, especially the computerization of the X-ray diffraction instrument used for mineralogical studies. Six PCs and a vehicle have also been purchased with SAREC funds. All members of staff now have their own PCs and e-mail facilities and there is a direct fax line to the IMR. Finally, the purchase of valuable databases and the upgrading of the IMR library are considered very helpful. Another major donor of research support for the IMR has been the IDRC of Canada, which supports an agrogeological network for Eastern and Southern

Africa to be managed by IMR. Further donations were received from several mining companies.

**The Mining and Processing Database.** In November, 1996, the Raw Materials Group, a private company in Stockholm, will install a database in IMR of well over 1 000 mining and processing operations in Zimbabwe. The database has been developed over several years (including a considerable delay) with the involvement of IMR staff. Such information has not earlier been available in the country. It will most likely be useful in several contexts, among these research projects. IMR staff will be able to benefit considerably from the database while it is doubtful to what extent the Ministry of Mines will have the capability to use it.

**Project Management.** The project is now to a large extent managed by IMR. For several reasons it is considered very important by IMR staff that they are financially responsible, for example for the purchase and maintenance of equipment. Previously, such tasks were carried out by the partners in Sweden. The Zimbabwean project participants consider SAREC more flexible and easier to work with than other similar agencies, for example with respect to choice of equipment and training courses, etc.. The earlier presence of a regional SAREC representative in Harare was considered particularly useful. Among the practical problems encountered were the delays in receiving SAREC funds and financial information through the Bursar's office at the University. IMR now keeps its own accounts in order to be able to check its financial status. This is in line with a general demand for increased accountability from all university departments.

### 3.2.2 Project Output

**Research Results.** In accordance with the general practices at IMR, most research results are published as reports with limited availability (Annex 4). Only a few regular scientific papers result from the project. Together with the limited cooperation on Campus, this may represent wasted opportunities for useful dissemination, even within the four projects supported by SAREC. Much of the research at the IMR focuses on the Great Dyke, which is also of interest in other projects. In particular, the Mineralogy and Economic Geology components fall into this category. The entire Great Dyke area is now owned by mining companies and exploration is intensive.

- **Mineralogy.** In recent years the mineralogical research has to a large extent been carried out in cooperation with overseas research institutions. It concentrates on mineralogical studies of Zimbabwean chromite ores, including the variation of magnetization with temperature. The latter studies were performed at the Geomagnetism Laboratory at the University of Liverpool in the UK. At the same time X-ray diffraction studies were carried out at the School of Physics and Space Research at the University of Birmingham. A long visit to the National Center for Electron Microscopy at the Lawrence Berkeley Laboratory in California with the purpose of carrying out microchemical analyses was very useful; so were hysteresis measurements carried out at the nearby School of Mining Engineering at the University of California. At home, both the upgraded X-ray diffraction facilities and the electron microprobe of IMR have been frequently used; the electron microprobe also by other university departments and by industry.

- **Metallurgy.** In a cooperation with Zimbabwean mining companies, the Royal Institute of Technology in Stockholm (KTH), and others, research has recently concentrated on the upgrading of high carbon ferrochrome through smelting reduction in which carbon was oxidized from the alloy. This was done with different chromite ore types and optimum operating conditions were determined. The quality improvements obtained in the upgraded product were investigated through a monitoring of the microstructure-physical properties.
- **Mineral Economics.** Much time has recently been spent on the completion of the Mining and Processing Database. Essential software, developed by the Raw Materials Group in Stockholm will be installed at IMR in late 1996. Even after this there will be a considerable amount of work left in Harare, before the database can be released for use by others. In addition to the work on the database, a feasibility study of stainless steel production for domestic consumption in Zimbabwe was started two years ago, but it was difficult to determine the amount and types of stainless steel used in the country. A severe constraint in this component has been the multitude of tasks placed on the key staff member, who is also a graduate student in Sweden (see below).
- **Environmental Geology.** Research projects are presently in progress within rock and environmental mechanics and environmental aspects of mining. There is an acute need of increased knowledge in both fields. Some rural areas are riddled with old mines which could easily collapse; they present a widespread danger to the local population. Gold-panning based on the formation of a one-to-one mercury-gold alloy and subsequent evaporation of the mercury component is carried out by families of squatters. The method used create serious health and environmental hazards for the local population. Good contacts have been made with a group of squatters who make their living in this way.

**Training.** Among the nineteen researchers at IMR involved in the project, three are presently pursuing graduate studies. Earlier one M.Sc. and one Ph.D. were trained under the project; the latter has now left the country for Australia. The three graduate programs in progress are all sandwich programs financed by SAREC.

- **Mineral Economics.** As a new initiative, one student has been following graduate courses in Mineral Economics at different Swedish universities as part of a Ph.D. program at Luleå University. It was necessary to attend several universities in order to locate the relevant courses taught in English. The studies are based on a sandwich model with an extensive course activity according to the Swedish system. Most courses have been attended at the Gothenburg University in Sweden (for six months) and at Luleå Technical University (for ten months). The periods in Sweden have been interrupted by longer periods in Harare during which, due to many other obligations, it has been difficult to concentrate on the thesis work. Both the student and his advisor at Luleå Technical University feel that more freedom in the planning of the SAREC sponsored sandwich program should have been allowed. In particular, it would have been better to complete all the eighteen months required for formal courses in Sweden, before starting on the research project. During the periods in Harare the student has had very extensive duties in addition to the work towards his degree. As an employee of IMR, he has not been able or willing to neglect the many demands for his time, which include work on the mining database. In addition there have been problems with the hardware and a promised assistant for data entry in the Mining database. Although the student feels that it would

have been easier to obtain a degree in Harare (which is primarily based on a thesis, with little coursework), he believes that he has learned much from the studies, in particular with respect to the planning of his work. A new workplan, in agreement with the advisor and IMR is now in place and the last study visit in Sweden is scheduled to commence in February, 1997.

- **Mineralogy.** A second graduate program deals with Mineralogy. Since it is directed towards a D.Phil. degree it does not contain formal courses, but many of the activities listed above in connection with the description of the research results within mineralogy (in particular research during study visits in the UK and USA) are important parts of the training towards this degree.
- **Metallurgy.** A third graduate program deals with Metallurgy and is carried out in cooperation with KTH, where fairly short (three months) visits have been made. It is expected to lead to a D.Phil. at the University of Zimbabwe in the autumn of 1997. The student expressed disappointment that no funds were available for publishing work (the practices by many research journals of demanding publication fees has an unfortunate effect in developing countries, where researchers often believe that they must be paid, while most researchers in industrial countries manage to avoid such fees) or for presenting research papers at international conferences. Despite a change of the Swedish supervisor, the student appeared well satisfied with the progress of the research work.
- **Environmental Geology.** A fourth graduate program, towards an M.Sc. in Environmental Engineering has now been completed at KTH in Stockholm. The study program consisted of course work at KTH (10 months), field work at the IMR (6 months) and thesis preparation at KTH (2 months). This M.Sc. student is now preparing to enroll as a Ph.D. student at KTH, the University of Cape Town, South Africa, or at a university in the Netherlands. He would prefer to follow a sandwich type program for his doctorate.

### 3.3 Groundwater Resources Development

**Background.** The support for groundwater resources development in Zimbabwe started in 1989 as a cooperation between the Department of Geology at the University of Zimbabwe and the Department of Engineering Geology at Lund University in Sweden. In 1991 a remote sensing component, based on Landsat images, was added. The project also includes a plant water use research component, carried out in cooperation with HRC, the Horticultural Research Center in Marondera, Zimbabwe. Support to the group for Groundwater Resources Development is also provided by Nuffic and a proposal to the German GTZ for support of groundwater monitoring is in progress. The main project components are:

- Hydrogeology,
- geophysics,
- remote sensing,
- hydrogeology and -chemistry, and
- plant water use

The purpose of the project is to build research capacity at the University of Zimbabwe within these general areas, particularly in relation to the knowledge and practical applications of shallow groundwater aquifer types (dambos) in the country. The horticultural component provides information on plant water use and soil moisture, information which is essential for practical applications in agriculture. The project partners at Lund University are primarily involved in geophysical and hydrochemical aspects of the project. Also a geophysicist from the Physics Department of the University of Zimbabwe is involved in the project.

The project has a significant potential, since the knowledge and use of groundwater in Zimbabwe is generally weak compared with that elsewhere in the region. The main reason is that the Ministry for Water Resources traditionally has relied on surface water for supplies to urban areas and irrigation. The studies are thus badly needed, also because the groundwater ecosystems are very sensitive, in relation to possible practical applications and to other activities in the environment, for example mining.

#### 3.3.1 Project Input and Management

**Input.** As shown in Table 2.1 the total SAREC support during the nine years the project has existed, amounts to almost SEK 5.5 million. A considerable part of these funds, over SEK one million, has been used to provide equipment for the activities in Zimbabwe, including a field drilling unit and field test pumping unit, support for geochemistry and hydrogeology laboratories, a remote sensing unit, two vehicles, and two trailers. Subscriptions to four research journals, numerous books, and specialized software have also been purchased with SAREC funds at the rate of around SEK 200 000.

**Project Management.** As discussed above, the SAREC funded activities allow a great degree of financial and administrative flexibility compared with practices common in other donor sponsored projects. This makes it possible to achieve maximum benefits from the funds provided. A local project participant expressed concerns that this flexibility might be reduced. A large share of the funds are administered in Zimbabwe where the relative strength of the infrastructure makes this easily possible. The managerial activities help create an essential research administration capacity, a component which is often missing in North-South donor sponsored projects (Thulstrup, Fekadu and Negewo, 1996). Among other benefits of the flexibility, it is considered to be of great help that SAREC funds may be used to pay salaries for research assistants - the Department is in tough competition for the best in this group - however, salaries of principal researchers can not be paid by SAREC funds. As in other projects there is considerable dissatisfaction with the services of the University Bursar's office, which is considered slow and difficult to work with. Especially the processes involved in the purchase of equipment are considered very bureaucratic.

**Cooperation with Sweden.** There is great satisfaction with the partnership with Lund University. The Swedish counterpart has been able to help introduce new and efficient electrical tomographical methods in Zimbabwe. The counterpart visits Harare regularly together with Swedish graduate students from Lund; these visits are considered very useful, in particular with respect to field work.

### 3.3.2 Project Output

**Research Results.** Extensive field work within the hydrogeological project component has produced useful results on several shallow aquifer types, including dambo wetlands. The research included also laboratory analyses in Harare. The field work was to some extent made possible through the participation of graduate students from Lund. The geophysical project component has successfully used a new 3-dimensional mapping of aquifer, based on electrical resistivity and radar penetration measurements, developed by the Swedish project partner. Also the remote sensing component attempts to locate and map aquifer in Zimbabwe. The hydrochemical activities target a determination of the recharge rates and the quality of groundwater and the horticultural component studies the relation between soil moisture and water use. The latter components have benefitted considerably from the end of the long draught in the region and they are expected to be concluded before the end of 1997.

The projects components have produced several research results of considerable interest. As shown in Table 2.2 and listed in Annex 4, the project has been able to regularly disseminate these results, sometimes in good, international scientific journals, but mostly in more user-oriented books and journals. Many results have been published in conference proceedings, as theses, or as posters at international conferences. Further dissemination has taken place at the training courses and seminars organized by the Group.

**Training.** As shown in Table 2.3 the project has produced twelve M.Sc.s, one in Zimbabwe and eleven in Sweden. Presently, three D.Phil. students are pursuing degrees at the University of Zimbabwe in Geology, Geophysics, and Remote Sensing. One of the students is expected to complete the degree work before the end of 1997. An M.Sc. student is presently working on completion of the degree at KTH in Stockholm and also expects to graduate in 1997. Furthermore, a number of technicians have been trained under the project.

A total of 10 scientists are involved in various research activities, which are supported by the project.

Local training has been performed during five training courses and four seminars, which have been organized in connection with the project. It is also worth noticing that two Swedish geology students from Lund have worked on their M. Sc. projects in Harare during three month periods with MFS support, which allowed them to take advantage of the outstanding opportunities for geological field work in Zimbabwe.

Also B.Sc. (Honors) students at the University of Zimbabwe may do fieldwork as part of their project, but funds are not always available for this. The costs are high; they include transportation, fieldwork expenses, salary living costs, and tuition fees. Presently, the only other possible source of support is industry, no such funds are available from the Government. The local project participants felt that SAREC support in the form of such B.Sc. (Honors) scholarships would be very valuable, both because of the research work that would be performed and because of the opportunity to recruit talents to the research field.

**Overseas Graduate Studies.** D.Phil. and M.Phil students are registered at the University of Zimbabwe, but perform part of their studies overseas. One student, from the Bulawayo area, has carried out studies both in Lund and at Aarhus University in Denmark with SAREC support. Among the many overseas activities under this project, experimental work has been carried out on the tunnel through Hallandsåsen in Sweden.

A second student with financing from both SAREC and Nuffic, The Netherlands, is presently in Amsterdam and has earlier studied remote sensing at the University of Southampton and the Institute of Hydrology in the U.K. The project participants recommend that SAREC provides full support for this student, as suggested in the coming application for renewal of the project funding. The student has recently upgraded his theses from M.Phil. to D.Phil.

A third student is about to complete his M.Sc. in Environmental Engineering and Sustainable Infrastructure at the Royal Institute of Technology (KTH) in Stockholm. The student will obtain a Swedish degree, which consists of nine months of course work combined with project work for three months. According to the bonding system described above, the graduate will then have an obligation to work as a lecturer at the University of Zimbabwe for two years.

### 3.3.3 Future Activities

**Regional Cooperation.** Lack of water for households and irrigation is a major problem in Africa (Sharma *et al*, 1996). Groundwater is one of the potentially very important solutions to the present problems. Nevertheless, the regional cooperation in Southern Africa within the field of groundwater is modest. One regional conference has been organised but it is felt that there has not been sufficient scientific overlap in the region to make more intensive cooperation worthwhile.

Although the quality of groundwater fieldwork is high in Botswana, it may not be well suited for the training of graduate students since the local expertise there is commercial rather than academic. However, cooperation in the form of shorter field visits in Botswana might be valuable. The University of Zimbabwe is considered to be the academic leader in geophysics

within the region, even in comparison with South Africa. It is felt that if there were to be a cooperative, regional training program within groundwater resources, the Department of Geology at the University of Zimbabwe would be a leading candidate to host it.

**The Sida Sustainable Water Supply Initiative under Consideration.** In this connection it must be mentioned that Sida is considering a large initiative for sustainable water management in the whole Southern African region (Granit and Johanssen, 1996). This may become very important for Zimbabwe which, in spite of the strong research base, is far behind other Southern African countries with respect to the practical use of groundwater. As mentioned above, the government has previously concentrated on surface water supplies to urban areas based on a historical division between agricultural and urban water supplies. It is felt that in particular the Ministry for Water Resources has been responsible for missed opportunities in this connection.

**Bulawayo Water Supply.** A proposal for a small extension of the project was submitted to SAREC in the summer of 1996. This proposal represents a joint effort by the project participants at the University of Lund and at the University of Zimbabwe. The background is the severe water shortage in Bulawayo, the second largest city of Zimbabwe with over a million inhabitants. A preliminary feasibility study showed that groundwater might be a valuable part of a short to medium term solution. Nevertheless, groundwater was not included in the final feasibility study of how to augment the water supply in Bulawayo. In order to provide the needed knowledge for inclusion of ground water, it is proposed to study relevant, existing geophysical and geological data together with data resulting from a limited amount of new information from geophysical field investigations. This will make it possible to estimate the thickness and boundaries of aquifer units and map other relevant aquifer properties. A Ph.D. student from Zimbabwe and M.Sc. students from Zimbabwe, Sweden (Lund University) and Denmark (Aarhus University) will be involved. The total costs are estimated to a little over SEK 200 000; almost half of this will be used for equipment for the field work.

**Other Future Needs.** At the moment there is a need for support for a D. Phil. student who can examine the role of indigenous woodland in the hydrogeological cycle. Also work on a hydrogeological map is considered a high priority; this task might be performed by an M.Phil. student. If the SAREC support were to cease many geophysical activities, which require extensive experimental work, would collapse, while the remote sensing activities would be able to continue because the direct costs are much lower.

### 3.4. Environmental Chemistry

**Background and Objectives.** The environmental chemistry project started in 1989 at the Chemistry Department of the University of Zimbabwe. The project is unique among the four natural science projects in that it has no Swedish counterpart. The main objectives of the program are to determine levels of different types of pollutants in air, soil and water in Zimbabwe and to carry out environmental impact assessment studies where pollutants have been identified. Other objectives are to disseminate, through scientific articles, seminars and media such as newspapers, information regarding environmental pollution in the country. Training students at the Master level (M. Phil.) in environmental sciences is an important part of the project. It is a long term goal of the project to assemble, in a series of books, a data base on the quality of air, soil and water in Zimbabwe.

#### 3.4.1 Project Input and Activities.

As indicated in Table 2.1, the annual SAREC support for the environmental chemistry project has been approximately SEK 400 000. Much of the funds have been used for purchase and maintenance of equipment including chromatographs and a vehicle. Approximately SEK 100 000 annually has been used on stipends for Master students.

**Main Research Areas.** The four main areas studied are:

- Pesticide levels in aquatic, terrestrial and agricultural systems,
- pollution of Zimbabwean lakes, in particular Lake Chivero,
- pollution of rivers and streams from mining operations, and
- air pollution, a new activity.

**Pesticides.** The work on pesticides has focused on the determination of DDT and metabolites such as endosulphan dieldrin and endrin. These agents are widely used in Zimbabwe in order to control tsetse flies and the spread of malaria. The studies include analysis of sediments in Lake Kariba and monitoring of crickets, spiders, grasshoppers, beetles, crocodiles and crocodile eggs. The analytical method used is capillary gas chromatography in combination with electron capture detectors subsequent to a clean-up procedure involving alumina, solvent extraction and evaporation. All equipment and instruments used in the studies had been purchased using SAREC funds. Part of the project was founded by the Research Board of the University of Zimbabwe. The results, published in a number of papers in the international literature, give a clear picture of the present situation of pesticide pollution in Zimbabwe as well as of rates of metabolism.

**Lake Chivero.** Lake Chivero is the main water supply for the approximately 1.5 million inhabitants of Harare. The pollution status of the lake is of great concern to the Harare authorities and is also well known among the population due to extensive reports in the local newspapers. On two occasions in the beginning of 1996, massive death of fish was reported

in the lake. This occurred again in October, 1996, during the Evaluation Team's field visit to the lake. There are several pollution sources. The catchment area of the three rivers flowing into the lake: Mhanyami, Mukuvisi and Marimba, is within heavily industrialised areas of Harare. This is an increasing problem since Harare is growing rapidly and the sewage plant capacity of the city is no longer sufficient. The effluents of the sewage plants reach Lake Chivero through the rivers and the presence of coliform bacteria has been reported. Approximately 160 million litres of sewage reach Lake Chivero every day. In addition there is a massive growth of water hyacinths in the lake and in the rivers. This plant was originally imported from South America as a pot plant and is now spreading rapidly in various parts of Africa.

The project participants have continually monitored the nutritional status of the lake with respect to phosphate, nitrate and ammonia. Phosphate concentrations in the range 6 - 9 parts per million (ppm) were invariably registered, the recommended maximum level being 0.3 ppm. In June and October nitrate levels were close to the maximum recommended value of 10 ppm. Due to the high concentrations of phosphate and nitrate, ammonia concentrations exceeding 3 ppm were registered, a value which is 30 times higher than the recommended maximum level. During an acute fish death situation the ammonia concentration reached a value of 3.5 ppm. The project also includes monitoring of the levels of dissolved oxygen (using the Winkler method) in Lake Chivero. Night values for the oxygen concentration were approximately 0.4 ppm which might cause fish death due to insufficient oxygen. During the daytime normal oxygen levels of approximately 5 ppm were restored by the extensive photosynthesis.

**Rivers.** The Chivero project also involves monitoring of toxic trace metals in the lake and feeding rivers. The analytical method used is solvent extraction followed by solvent evaporation and finally determination by flame atomic absorption analysis. Unfortunately, the research group has not had access to a graphite furnace atomic absorption analyser. In the Mukuvisi River the levels of copper, zinc, lead, cobalt, iron, nickel, and chromium(III) were monitored. At certain sampling points lead concentrations close to four ppm were registered. This is approximately a factor of eighty above the World Health Organisation's (WHO) recommended highest level for drinking water. Chromium concentrations exceeded the recommended value by a factor of three to five.

The mine waste activity in the project has mainly been concerned with the determination of cyanide from gold mining plants. Two plants situated approximately 50 km from Harare have been targeted. The analytical method used involves derivatization of cyanide to 1-benzoyl-1,2-dihydroquinaldo-nitrole prior to liquid chromatography measurements on a C<sub>18</sub> stationary phase. The equipment used has been purchased with SAREC funds. The results indicate that the cyanide levels drop rapidly downstream of the gold processing plant, probably due to rapid biodegradation, complex formation with iron(II) and dilution. Even so, cyanide levels exceeding the recommended value by a factor of two were registered both in polluted and in what earlier was considered to be non-polluted water close to Harare.

### 3.4.2 Project Management

The project is unique among the natural science projects in Zimbabwe in that it has no Swedish counterpart, although some cooperation with KTH in Stockholm has taken place. Nevertheless, the project is very efficient and well managed and the output in terms of scientific publications and student training most satisfactory. Considering the limited amount of funds provided, the project must be characterized as being very cost-effective.

**Equipment Needs.** Equipment needs are modest, partly because of the Japanese grant. However, in the coming budgets, high priority might be given to the purchase of a graphite furnace atomic absorption analyser, increased funds for M. Phil and D. Phil students, maintenance and upgrading of the currently used, very substantial instrumentation, library facilities, purchase of personal computers and, last but not least, installation of e-mail facilities. In particular, a graphite furnace would facilitate the study of toxic metals and improve detection limits. The project group has the competence to make optimum use of this instrument. In general, the group might benefit from more frequent use of the sophisticated instrumentation available at the Chemistry Department, but lack of manpower puts some limits to this.

**Competition for Talent.** The project is particularly vulnerable because of the difficulty in retaining M. Phil. and D. Phil. students working within the group. After some training these students are offered considerably higher salaries by industry. Increased funds for stipends to such students, making it both possible and attractive for them to complete their studies, are urgently needed. This would not only help satisfy manpower needs in industry and at the University of Zimbabwe but might also help provide the new universities in Zimbabwe with urgently needed research trained personnel.

**Extension of the Group to Bulawayo.** In the near future a senior member of the Environmental Chemistry Group will leave to take up a position at the new National University for Science and Technology in Bulawayo. This represents a unique opportunity to recruit new talent and to disseminate knowledge to a wider audience. It will also be possible to start field work in new areas. The group plans to take full advantage of this opportunity.

**Cooperation Between SAREC Sponsored Projects.** The Environmental Chemistry Group might benefit from a more active cooperation with other SAREC projects in Harare. For example, the trace elements studies could benefit from a strengthened cooperation with the environmental program in the Institute for Mining Research (IMR), which gives the the Environmental Chemistry Group access to much relevant equipment, e.g. the atomic emission spectroscopy facilities.

Although the Environmental Chemistry Group finds that it takes full advantage of the extensive instrumentation in the Department, the pesticide project might benefit from more frequent use of the excellent gas chromatography-mass spectrometry (GC-MS) facilities in the Department. This would make it possible for additional peaks in the chromatograms to be assigned. The other SAREC supported groups might benefit considerably from a strengthened cooperation with the Environmental Chemistry Group on aspects of common interest. SAREC (Sida) might facilitate such cooperation by encouraging regular (for example, annual) seminar/workshops for participants in the four natural science projects, possibly including participation from relevant projects elsewhere in the region.

### 3.4.3 Project Output

**Scientific Publications.** The project group publish extensively in the international literature on subjects within applied environmental chemistry. Journals used are, for example: *The Science of the Total Environment*, *International Journal of Toxicology*, *Occupational and Environmental Health*, *Journal of Environmental Science and Health*, and *Water, Air and Soil Pollution* (see Table 2.2 and Annex 4). In addition the group has published articles on fundamental aspects of atomisation processes in flame atomic absorption spectroscopy. The project group has contributed with several presentations, also in the form of articles for conference proceedings, at national, regional and international conferences and workshops.

**Training.** An important part of the project is training of students in environmental science and awareness of environmental issues. In the period 1989 - 1996 the three senior scientists of the project group have supervised 24 M.Sc or M. Phil. theses. In addition 14 undergraduate honours research projects have been supervised. Two M. Sc. students from the Royal Institute of Technology (KTH), Stockholm have completed their project work in the research group. Also former students from the Chemistry Department have been trained in environmental issues by providing them employment in time-limited positions as research assistants, thereby giving them an opportunity to work within environmental research. A joint seminar on Environmental Engineering and Technology in cooperation with KTH, Stockholm, is planned to take place in early 1997.

**Dissemination to the General Public: Newspapers and Other Media.** The project leader has been active in making the research results known to the public, primarily through the Zimbabwean newspapers and TV.

## 4. Conclusions and Recommendations

### 4.1 General Conclusions and Recommendations

**Impact of SAREC Funding.** The contribution of SAREC to the capacity building within the four natural science projects at the University of Zimbabwe has clearly been crucial. It is to a large extent due to this support that the four projects have developed into productive research activities at good, international quality levels. This has also strengthened the host departments. Support from SAREC to the infrastructure at the University of Zimbabwe (the Main Library, financial management, etc.) is also contributing to the success of local research activities.

**Sustainability of the Projects.** The four projects have all reached a level where they are able to independently carry out research and research training at a good international level. However, due to the severe financial constraints within the University and the public sector in general, and due to the long term understaffing of the host institutions for the projects, the high standards are hardly sustainable without outside assistance. In other words, although the projects produce valuable national benefits in the form of research results and research based training, the nation is unable to pay for these services at a proper level. If SAREC withdraws its support, which is particularly valuable because of its flexibility, the projects are likely to experience severe problems and will not be able to sustain their present good quality and productivity. There are, however, some possibilities for income earning activities by the projects, both through improved industrial contacts, and, especially, through the provision of new services to the country and region.

**Cooperation On and Outside Campus.** All four projects carry out extensive, international research cooperation, including partnerships with Swedish institutions. Except in the case of the Environmental Chemistry project, Swedish partners have been selected as part of the SAREC projects and they receive compensation from SAREC for their services. In general these partnerships are productive and satisfy fully the expectations of the Zimbabwean partners.

The cooperative climate on the University of Zimbabwe Campus is not always perfect, neither between the SAREC sponsored projects, nor otherwise. Three of the projects, Chromite Mining, Groundwater Development, and Environmental Chemistry have considerable overlaps, for example in the analytical chemistry field, and might benefit from a more effective sharing of instrumentation and expertise. Similarly, the Protein Biotechnology Project has not attempted to take advantage of the extensive facilities available in the Chemistry Department. A lack of interest in domestic cooperation seems to be a common problem within the University. Also cooperation with industry is not always satisfactory. It is strongly recommended that local cooperative opportunities are used as much as possible. Stronger initiatives, for example with regard to course offerings to industry and the relevant public sectors as well as organization of regular seminars for both SAREC sponsored projects and industry may improve the communication. The relative lack of power given to Department Chairpersons and Deans does not improve the situation. If they were given more influence, cooperative initiatives might be more likely to succeed.

**Research School for Mineral Resources.** In this connection, the earth sciences represent a particularly important case. After some failed attempts to pool the human and equipment resources on campus within the field of minerals, a looser structure has now been proposed in a recent evaluation (Nuffic, 1996). Since the advantages of such a pooling are considerable, the Evaluation Team recommends that this proposal is seriously considered in spite of the difficulties which cannot be ignored.

**Recruitment Problems.** A perennial problem in many Third World countries, including Zimbabwe, is the inadequate salaries paid to the academic staff in universities. This makes it very hard for the SAREC supported projects to compete with the active industrial sector in the country for new talent. Economic support and other incentives for young graduates to enter research are much needed. Similarly, improved opportunities for employment in post-doctoral positions are likely to improve both the research productivity in the projects and the recruitment of young researchers to the four fields.

When Zimbabwean industry depopulates the universities, it also reduces their capacity for production of new graduates. In a sense this corresponds to eating a hen that produces valuable eggs. With improved industrial contacts, each project might be able to convince industry about its own long term interests in replacing competition for scientific talent with cooperation aimed at producing as many research trained graduates as possible.

**Financial Services at the University of Zimbabwe.** In a support system which is otherwise efficient, direct, nonbureaucratic, and well liked - individual projects communicate directly with SAREC, with a minimum of university involvement - there is widespread dissatisfaction with the services of the University Bursar's Office. In particular the fact that it takes a very long time for funds from the Swedish Embassy to reach the projects gives rise to widespread dissatisfaction.

Except for this problem - which so far has not been reduced by the attempts by SAREC to strengthen the financial services at the University - the university administration interferes very little with the provision of foreign support. While it does not charge any overhead, the University is likely to have considerable interest earnings from foreign grants (annual interest rates in Zimbabwe are over 20%), at a level which might replace a reasonable overhead charge. Unfortunately, this weakens the incentive system in the university administration for punctual handling of funds.

**New Managerial Tasks.** The lack of involvement by management, at both the university and faculty levels may initially be seen as an advantage, since it reduces the amount of bureaucracy and red tape. On the other hand, it also represents wasted opportunities. There is, for example, little doubt that many donors are seriously interested in providing further support for scientific research in Zimbabwe; it would facilitate and simplify the process if the Science Faculty could assist more actively, based on a strong insight, both in the local research capability and needs and in the potential outside donors.

## 4.2 Conclusions and Recommendation: The Projects

### 4.2.1 Protein Biotechnology

Out of the eight members of staff in the Biochemistry Department, who are active in research, three are supported by SAREC. Together with the students who have been educated both at the level of M.Sc. and D.Phil., they form a considerable body of expertise. The Department has also benefitted from SAREC support through the purchase of equipment which in most respects is kept in satisfactory working order. On the whole, the support from SAREC has been essential for the creation of one of the strongest biochemistry departments in Africa. Nevertheless, some improvements are possible.

**Weak Applications of Molecular Biology.** One weakness observed is that there is a lack of applications of molecular biology in the Department. Today, good research must apply the most appropriate methods and some of these will surely be within the field of molecular biology. At least some of the needed methodologies should be available in Harare, while other methods may require cooperation with overseas researchers.

**Medicinal Plants.** In view of the wealth of plant substances with medical properties in Zimbabwe international cooperation in the field of medicinal plants should be easy to establish on the basis of sound research plans and clear objectives. One example is the isolation of novel lipids with interesting dietary and medical properties such as those from the Evening Primrose. The Natural Product Group in the Chemistry Department has considerable experience with the extraction of substances of medical interest. A closer cooperation with this group might be very useful.

**Cooperation with Industry.** With its good standards it is disappointing that the Protein Biotechnology Group does not collaborate more with industry and with other research institutions in Zimbabwe. While the first priority in the Department has been to establish research capacity, the time has now come for a greater industrial involvement. It was not possible for the Team to assess the needs of industry in Zimbabwe for such cooperation, but it may be noted that the new Science and Technology University in Bulawayo is already engaged in sandwich courses with industry. The Protein Biotechnology group should be in an even better position for offering relevant courses to industry; short term, well targeted courses may be a useful starting point for improved industrial cooperation.

The project may approach the Scientific and Industrial Research Development Park (SIRDC) concerning the establishment of further industrial links. Among the research institutes, it was observed that the Kutsaga Research Centre of the Tobacco Research Board had spare capacity and cooperation with them in the area of crop sciences might be very beneficial. Within the University cooperation with the Pathology Department of the Medical School should also be explored, especially for the development of diagnostics kits. These should include DNA profiling which now has wide applications both in medicine and food science. Also opportunities for instrumentation use in the well equipped Chemistry Department should be further explored.

**Possible Expansion of the Group.** Such expanded activities may not be realistic without an expanded group. An expert in plant lipases is ready to be appointed to an established post in

the Department. It may also be worth considering an expansion of the staff with an environmental expert.

**Management of the Project.** Generally, the project is well managed. The only weakness noticed is that the academic staff at the University of Lund, responsible for the training of students from Harare during their visits in Lund, should be more involved in the planning of the individual research projects from the outset. One or more visits in Harare may also be needed.

**Library Problems.** The provision of relevant literature, both in the Main Library and within the Department is unsatisfactory. A determined effort should be made by the Department to ensure that individuals who obtain their own journals, for example through SAREC, make these generally available in the Department. Although Internet services are likely to be useful, a total reliance should not be placed on them.

## 4.2.2 Chromite Mining and Ferrochrome Smelting

**New Fields.** As part of the IMR, the project receives domestic funding from the Ministry of Mines, including considerable amounts of modern equipment and funds for its operation. This places it in a somewhat better situation than the other three projects. Nevertheless, without the support from SAREC it would not have been possible to develop the new, important activities within Mineral Economics and Environmental Geology. With the expanding interest for new mining activities in Zimbabwe, Mineral Economics is growing in importance. This is a particular concern for the larger mining companies. Also Environmental Geology is increasingly in focus; there is an acute need in the country to develop safer techniques for gold mining and to disseminate information on the hazards involved to both miners and the environment, for example in connection with the use of mercury for gold extraction. This is an obvious target for increased project activity.

**New Name.** Since the project has changed its emphasis in recent years and since future project activities are likely to include several outside the chromite mining field, it is suggested that the project is renamed in connection with the upcoming negotiations. In particular, a reference to Environmental Geology should be considered.

**Continued Need for Sandwich Type Research Training.** The major need for SAREC funding is presently related to the research training of IMR staff, especially in the two new fields. In spite of some problems, sandwich model training seems to be the most efficient method at the moment. The problems encountered (and now hopefully solved) in one of the graduate sandwich programs with Sweden have produced at least two useful lessons: 1) Flexibility in the time schedule for sandwich programs is necessary (e.g. it should be possible to complete all course activities during a single, extended stay in Sweden) and 2) the IMR must secure sufficient freedom and technical assistance for staff pursuing research degrees, also during their stays in Harare. Finally, it is important that the IMR take advantage of all opportunities for increased cooperation with the other SAREC sponsored projects on Campus as well as with other relevant university research activities.

**The Mining Database.** Installation of essential software at IMR is planned for late 1996. It will be useful for IMR in several ways, for example in the two new fields. The database is

financed by a separate grant which is not expected to be continued beyond the present commitment, which still includes a considerable amount of work in Harare. IMR must ensure that the valuable information contained in the database becomes available to all potential users.

### 4.2.3 Groundwater Resources Development

**The Use of Groundwater in Zimbabwe.** Groundwater is a potential resource which, for historical reasons, is poorly exploited in Zimbabwe. The SAREC sponsored development of the field in the Department of Geology provides a solid research base for future exploitation of groundwater, both in the country and in the region (see below).

**Research Results and Training.** It seems likely that the hydrogeology, hydrochemistry, and plant water use components will come to a successful conclusion by the end of 1997. Part of this achievement would be the completion of the D.Phil thesis of the senior project manager in Harare. The remote sensing component is still in a build-up phase and will need support, especially in the form of training, at least until the end of the century. The geophysical component has started promising activities in the Bulawayo area where some of the largest aquifers in Zimbabwe are found. The continuation of these activities, in cooperation with Lund University, is important and a small proposal has already been submitted.

The development of the group in Harare would not have succeeded so well without an efficient cooperation with the Swedish partner. In particular research training has progressed very effectively in this model; this has included training of a large number of Swedish students in Zimbabwe, an activity which led to considerable progress in the geophysical field work. Unfortunately, the local funds, both for salaries for graduate students in Harare and for field work, are now very limited. It is expected that recruitment of new talent to the project may become an even more serious problem.

**Regional Support for a Sustainable Water Supply Project.** The Groundwater group in Harare represents a considerable part of the regional academic expertise in the field. It will be a strong candidate for provision of research based training in the field of groundwater development at a regional level, even for countries with stronger traditions for the practical use of groundwater. This may be of importance in connection with the Sida sponsored sustainable water supply initiative for the region, which is presently under consideration.

### 4.2.4 Environmental Chemistry

**High Standards.** Even without the support of a permanent Swedish partner and with the lowest costs to SAREC among the four projects, the Environmental Chemistry project has progressed to a very high level of competence and relevance in the work. The group produces results of considerable interest, both in basic analytical chemistry and in applied environmental chemistry. The group attempts to disseminate the latter results to local users in need of such information. On the whole, the activities form an excellent basis for relevant research training.

**Research Training.** Tough competition for young talent, especially from industry, makes it difficult for the group to retain the best students. This is particularly disappointing because of the extensive modern instrumentation which is now available in the Chemistry Department. With the availability of more manpower, both in the form of graduate students and post-doctoral fellows, the Environmental Chemistry Group might be able to benefit much more from these facilities.

## 4.3 Conclusions and Recommendations: SAREC

**Need for Continued SAREC Involvement.** The support from SAREC has functioned well, with modest bureaucracy and a large degree of flexibility. Among the project participants in Harare, there is in general considerable satisfaction with the way the support has been provided. In spite of the solid research capacity created and the significant support from many other donors, continued involvement by SAREC is crucial for the future success of all four projects. The main reason is the disappearance of local research funds and the fact that few other donors allow for the flexibility in the use of funds that SAREC does.

Similarly, a withdrawal of the general university support through SAREC, for example for the Main Library at the University of Zimbabwe, would be disastrous, although SAREC should carefully monitor the planned development of Internet services in the Library. Thus, in spite of the considerable research capacity already created, the Team recommends that continued support is provided, both for all four projects, though at different levels (see below) and for the University of Zimbabwe.

**Provision of Incentives.** SAREC has a policy of not supplementing salaries for senior staff. Although there are clear reasons for this strategy, it may occasionally be necessary to allow considerable flexibility in order to create additional incentives for the key research staff so that a total dedication to the projects can be maintained. Incentives for younger staff may be provided by SAREC in the form of stipends for graduate students and, in particular, post-doctoral fellowships in the four projects.

**Contact with Industry.** Incentives for improved industrial contacts may also be considered, for example through grants covering the cost of short term training courses directed towards industry and public sector staff. While the financing of such courses in the long run should be taken care of by the users, free course opportunities at first may help ensure sufficient participation in the activities.

**Regional Services.** As a condition for continued, and in some cases increased, funding SAREC may consider a gradual change of the strategy within the natural science projects in Zimbabwe. SAREC may, in return for the funding, expect the projects to take responsibility for research training and (for example in the case of IMR) research services for a wider audience, both within the new universities in Zimbabwe and in other parts of the region. There exists in Southern Africa a considerable need for research training. It might be highly efficient to match this need with the demand, which exists in all four projects, for talented manpower, in the form of graduate students. During the Evaluation Team's mission all four projects expressed interest in taking on a regional responsibility. The practical details in connection with such arrangements might be discussed during the upcoming budget negotiations between SAREC and the projects.

**Cooperation and Communication between SAREC Projects.** The Evaluation Team found that individual scientists working in the four projects funded by SAREC might benefit from an exchange of information on both scientific and practical matters and, in a few cases, from increased scientific collaboration. SAREC might encourage this by supporting joint one day seminars/workshops at regular intervals (annually or biannually) at which both scientific problems, dissemination of information, and issues in connection with the cooperation with Sweden and with industry might be discussed. Several project participants mentioned that

the earlier presence of a SAREC regional representative in Harare had been very useful; an involvement of the Harare Embassy in seminars for Zimbabwean project participants and relevant staff from industry might help further increase the communication between Embassy staff and the projects.

**The Bursar's Office.** As a small added advantage, this might also provide easier insight in the slow flow of funds from the Embassy to the projects. The Evaluation Team recommends that Sida staff in Harare attempt to solve this problem in cooperation with the University Bursar's Office.

**Flexibility in the Sandwich Programs.** In one of the projects it was felt that the conditions for visits in Sweden in connection with a Ph.D. sandwich program were too strict. It seems reasonable that graduate students and their advisors within the given budget have a considerable say with regard to the timing of study visits in Sweden.

**Cost Effectiveness and Fees Charged in Sweden.** It is estimated that the cost effectiveness of the projects is good compared with other international costs for research training, especially for the Environmental Chemistry Project. A further improved cost-benefit ratio might be obtained if each Swedish supervisor accepted a higher number of students within the sandwich programs. Overheads and tuition fees paid to Swedish institutions are not standardized but must be carefully scrutinised by SAREC staff in each case. This is time consuming and may cause misunderstandings, although most fees are likely to be very reasonable. It is recommended that SAREC makes an attempt to standardize the fees.

**Reporting and Evaluation.** The four individual projects normally report annually to SAREC, but these practices are not standardized - some felt that they volunteered such information, and that it was not required. In some cases copies of reports were sent to the management at the University of Zimbabwe, but neither this was standard practice. The projects participants felt that proper evaluations were rare. A standardization of the reporting procedures, e.g. based on report forms, would be helpful in several respects, both for the project participants and for SAREC staff. Such a standardization has successfully been introduced in the Danish ENRECA program (Danida, 1992). In connection with the four projects in Zimbabwe, SAREC provided complete information about the monetary input, while systematical information on the even more important project outputs (research results and training) was not directly available. It is important that SAREC monitors project outputs as systematically as project inputs and that the importance of outputs is constantly emphasized.

**Local Management.** SAREC may consider providing more general support at the faculty level, so that a proper registration and monitoring of (but not a bureaucratic interference with) research input and output can be performed. This should also include information on potential funding sources, etc., so that the faculty might better facilitate contacts with potential donors. The ability of the Faculty of Science in this field might be tested and strengthened through negotiations about possible new SAREC sponsored projects. Improved scientific contacts between Swedish and Zimbabwean researchers might be established through SAREC sponsored travel grants for external examiners from Sweden. Stronger and more powerful managements in the Science Faculty and its departments might simplify larger cooperative initiatives and create a stronger base for individual research projects.

**Biotechnology.** The main deficiency in this project is the comparative lack of industrial involvement which is after all the major *raison d'être* for a biotechnology group. It would be a pity if SAREC, with the considerable expertise of Sweden in the collaboration between academia and industry, could not see through a number of fruitful collaborations. SAREC might consider a budgetary expansion in connection with a few new staff members whose salaries would be met by the University of Zimbabwe. In the long run, fruitful collaboration with industry would do much to justify to Government support for biotechnology in the university. A widening of the project scope in this direction should be supported, e.g. through grants for short-term courses for industry.

Consequently, continued support along the present lines, preferably at an increased level, is strongly recommended by the Evaluation Team. In addition, SAREC support for biotechnology journals in the Main Library should be extended to include review journals covering more fundamental aspects of biochemistry, or such journals should be part of the regular provisions for the project (possibly in the form of inexpensive personal subscriptions).

**Chromite Mining and Ferrochrome Smelting.** The major need in this project is graduate (degree) training of the IMR staff, in particular within the new field, Environmental Geology. Many of the present practices, especially in small scale gold mining, represent a severe risk to both miners and the environment and the field seems to be an important area for environmental research. In other fields, SAREC should support a continuation of training programs at the present level. At the moment, it seems that other major needs, especially instrumentation, are covered by the Ministry of Mines.

The project has in recent years shown a willingness to enter new, important fields; the Evaluation Team recommends that SAREC also in the future supports such initiatives.

**Groundwater Resources Development.** While the hydrogeology, hydrochemistry, and plant water use components are near completion and will need only minor support beyond the present budget, the remaining components (remote sensing and geophysics) of the Groundwater Project should be supported for the rest of the century, at least at the present level. This should include funding for the proposed, small Bulawayo project. An expansion of the support is likely to be necessary if the project is given a larger regional responsibility, for example in connection with the proposed Sida regional initiative for sustainable water supply (Granit and Johansson, 1996).

Both in relation to IMR and the Geology Department, further SAREC support may provide needed incentives for the establishment of a formal cooperative earth sciences unit, a "Research School of Mineral Resources" on Campus. It is important that also IMR be included in such a unit, both because of the expertise and information services available in IMR and because of the extensive, specialized equipment which is in operation in the Institute.

**Environmental Chemistry.** Further SAREC support is necessary in order to secure a continuation of the high productivity and excellent quality of this project. The Evaluation Team recommends funding at a higher level, in particular to cover operational expenses, subsistence, and other costs. The latter would include improved incentives, which are needed to attract and train a larger number of graduate students in the group. Full advantage should

be taken of the opportunities for an expansion of the project to Bulawayo, which will result from the move of a senior staff member from the group to the National University for Science and Technology. This must be considered a unique opportunity for SAREC to become involved with this new and important university.

**The Chemistry Department.** In addition to the four projects, the Evaluation Team made a general assessment of opportunities within the Chemistry Department. This extremely well equipped Department is well managed, maintains generally high standards and attracts very good students, but it lacks funding for more extensive graduate programs. The shortages include both operational and maintenance costs for the extensive modern equipment in the Department, senior research staff (many positions are vacant), and competitive salaries for graduate students. It is recommended that SAREC starts a dialogue with the Department and Faculty about support for future projects. Such projects might be designed so that they also benefit the new universities in Zimbabwe and other, less developed, parts of the region. In particular, the possibilities for scientific research collaboration and joint sandwich programs between the universities in Harare and Maputo should be investigated. The projects might possibly include partnerships with Swedish universities, and should in any case provide opportunities for international exposure to both graduate students and staff in the Department.

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# Annex 1

## TERMS OF REFERENCE FOR AN EVALUATION OF SAREC's SUPPORT TO ZIMBABWE IN THE AREA OF NATURAL SCIENCES

### 1. Background

Since 1980's SAREC has provided support for research and research capacity building in the area of natural sciences at the University of Zimbabwe and at the Zimbabwean Institute of Mining Research, located at the University. The support is part of the Swedish bilateral research cooperation with Zimbabwe. During 1988/89 - 1996/97 SAREC's support to the area of natural sciences amounts to 24 million SEK, i.e. approximately 34 % of SAREC's total support to Zimbabwe during the same period.

The purpose of the evaluation is to assess the impact and efficiency of the support with regard to development of research capacity on the individual (research group) level, and on the institutional and national level. An additional aim is to assess the relevance and importance of the scientific results obtained.

SAREC's current agreement on bilateral cooperation with Zimbabwe comes to a end in June 1997. The report from this evaluation is expected to serve as an input into Sida/SAREC's<sup>1</sup> decision regarding future support to natural sciences in Zimbabwe.

### 2. SAREC's objectives and mode of operation

SAREC's main objectives in providing support to bilateral research cooperation with Zimbabwe are:

- to assist in the creation and strengthening of research capacity suitable to Zimbabwean conditions and in line with Zimbabwean development strategy,
- to promote research work of high relevance to the development of Zimbabwe.

For achieving these objectives SAREC has structured its support to integrated project and training activities. Training of researchers may be arranged as "sandwich" programs, i.e., periods of training and field or laboratory work alternately at the home institution and at the cooperating institution. In most projects, transfer of knowledge is

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<sup>1</sup> Since July 1995 SAREC is the Department for Research Cooperation at Sida, The Swedish International Development Cooperation Agency.

promoted through a close cooperation between Zimbabwean scientists and Swedish universities. Within the framework of the research project, support is also given for purchase of equipment, spare parts, consumables, etc., and for salaries or stipends to Zimbabwean technicians and postgraduate students connected to the projects. Financial support may also be given for arrangement of courses, symposia and workshops.

### **3. Scientific areas supported**

Under SAREC's current Agreement with the University of Zimbabwe, four projects are being supported in the following areas:

Protein Biotechnology  
Environmental Chemistry  
Groundwater Resources Development  
Development of Chromite Mining and Ferrochrome  
Smelting

The first three of these projects are based at the University of Zimbabwe and the fourth at the Institute of Mining Research, located at the University. The support to these projects comprises financial support, training, strengthening of research infrastructure, and regarding three of the projects, cooperation with Swedish institutions. Annex 1 provides a brief summary of the projects together with the names of cooperating institutions, project leaders and budgets.

### **4. Terms of Reference**

#### 4.1 Evaluation of cooperation

The evaluators shall perform the following tasks.

##### Description of:

- 4.1.1 The institutions involved in the cooperation (a brief overview), and their relative importance for Science and Technology development in Zimbabwe.
- 4.1.2 Ongoing activities on the faculty or institute (IMR) level in relation to their research priority setting.
- 4.1.3 Financial support to research activities, including national budget resources and external donors presently supporting research activities at the cooperating faculty/institute.
- 4.1.4 General description and assessment of the projects in relation to the objectives of SAREC and the specific objectives of each project as described in the project documentation.

Assessment of:

- 4.1.5 Relevance of the projects to the scientific and technological development in general and particularly in Zimbabwe.
- 4.1.6 Contribution to the creating and strengthening of research capacity at the Zimbabwean institutions involved, with particular attention to
  - the development of critical research capacity through research training on MSc/PhD levels built into the projects,
  - the fostering of the ability to identify and define research problems and plan and execute projects,
  - the building-up and maintenance of the research facilities.
- 4.1.7 Experience of research cooperation with the collaborating institutions; the role of the Swedish institutions: mutual cooperation, training, advisor and facilitator.
- 4.1.8 Cost-effectiveness. The cost-effectiveness of various elements in the cooperation should be discussed, e.g. research training and supervision according to the "sandwich model" in relation to alternative training models, travel by students and supervisors, research administration and overhead charges.
- 4.1.9 Output in terms of both quantity and quality in relation to the projects' duration and funding so far, e.g. recruitment for research, staff training opportunities, examination of students. A list of publications will be attached to the evaluation report.
- 4.1.10 Sustainability. An opinion will be given on the viability of the research presently supported by SAREC, longterm sustainability as well as institutional impact. Sustainability with regard to training, research production (production of publications, dissemination of results, links to society), and research administration (organization of research, research administration at the faculty/institution, availability of research funding).

4.2. Recommendations by the Evaluators

In addition to the above, the evaluators shall

- 4.2.1 Draw conclusions and make recommendations in respect of the possible continuation of activities, organization and financing with or without further Swedish assistance.
- 4.2.2 Assess the feasibility of linking the thematic research in

the above named projects with faculty support in order to create sustainable conditions for research and research management in the faculty. The balance between project support and faculty support (as presented in the report, "The Ownership and Cultivation of Knowledge" (Annex 2) will be discussed.

- 4.2.3 Propose general measures to be taken in view of any obstacles in the cooperation identified by the evaluators.
- 4.2.4 Propose measures to increase the cost-effectiveness of the projects.
- 4.2.5 The evaluators may suggest research areas which SAREC should take into account in the preparation of future proposals for research cooperation with the University of Zimbabwe within the area of natural sciences, especially within the chemical sciences and science related to water resources and water resources management.

The evaluators are free to add and comment upon issues of relevance to the projects apart from what has been described in this Terms of Reference. Besides the project leaders, the evaluators may also discuss with whoever they find suitable for extracting important information.

The evaluators will be briefed by SAREC and arrangements will be made to meet with the Swedish counterparts of the projects in Sweden.

## **5. Evaluators**

The evaluation will be carried out by a team of three consultants, one of them will be assigned as a team leader.

## **6. Time table and Reporting**

The evaluation visits will take place during September - October 1996. A draft report in English will be presented to Sida/SAREC not later than 15 December 1996. A final report will be presented no later than 3 weeks after the team leader has received SAREC's, University of Zimbabwe's and IMR's comments on the draft report.

The team leader is responsible for compilation of the findings and reporting the evaluation to Sida/SAREC. The final report shall be delivered on paper as well as diskette (compatible with Word Perfect 6.1 for Windows) and follow the enclosed format for consultancy reports (Annex 4). The report should begin with an executive summary of not more than three pages and close with a section containing the evaluator's conclusions and recommendations in particular on SAREC's possible future support to Zimbabwe in the named research areas.

The report will be made public and it will be used and distributed by Sida/SAREC in its entirety or in parts. The final report will be published in the Sida Evaluations series. A special form "Sida Evaluations Data Worksheet" has to be filled in for the Evaluation Unit.

Enclosures:

Annex 1. SAREC supported bilateral research cooperation with Zimbabwe in the area of natural sciences during 1989/90 - 1996/97: Project Abstracts and Budgets.

Annex 2. SIDA/SAREC report: "The Ownership and Cultivation of Knowledge, the rationale for Swedish support to universities in developing countries".

Annex 3. M R Bhagavan: "The SAREC model: Institutional cooperation and the strengthening of national research capacity in developing countries"

Annex 4. Sida Evaluations Newsletter: Instructions for Evaluation Managers and Consultants.

Annex 5. Sida Evaluations Data Worksheet.



## **Annex 2**

### **Institutions Visited and Persons Met During the Missions.**

Peter N. Campbell was in Zimbabwe between September 7 and 21, where he, in addition to visiting a key staff member of the National University of Science and Technology in Bulawayo, spent most time at the University of Zimbabwe in Harare. Later, he visited Lund University (October 8-9), and on October 9 he met with Erik W. Thulstrup at Copenhagen Airport.

Daniel Jagner was in Zimbabwe between October 23 and 30 where he visited project activities in Harare and field research sites in the vicinity of Harare.

Erik W. Thulstrup visited Stockholm on October 8 in order to meet SAREC staff and project participants. He was in Zimbabwe between October 23 and November 2 in order to visit project activities in and near Harare.

Individual Team members met with the following key persons:

#### **In Sweden**

##### **Sida (SAREC), Stockholm:**

G. Hedebrö  
M. Lindroos

##### **Raw Materials Group, Stockholm:**

M. Ericsson  
A. Tegen

##### **SNS Energy, Stockholm**

M. Radetzski (also representing Luleå Technical University)

##### **Dept. of Biotechnology, Univ. of Lund**

B. Mattiasson

#### **In Zimbabwe**

##### **Swedish Embassy, Harare**

J. Granit  
T. Ngwenya  
J. Olsson

**Dept. of Applied Biology and Biochemistry at the  
Nat'l University of Science and Technology, Bulawayo**  
T. G. Djarova, Chairman

**Scientific and Industrial Research and Development Center**  
C. J. Chetsanga, Director General

**University of Zimbabwe**  
F. W. Graham Hill, Acting Vice-Chancellor  
L. M. Nyagura, Pro-Vice-Chancellor  
M. S. Murandu, Director, Intern. and Public Relations

**Faculty of Science, Univ. of Zimbabwe**  
H. A. M. Dzinotyiwei, Dean  
J. G. Zengeni, Deputy Dean

**Department of Biochemistry, Univ. of Zimbabwe**  
M. Benhura  
J. Read  
R. Zwauya  
Zimbabwean and Swedish graduate students

**Institute of Mining Research at the Campus of Univ. of Zimbabwe**  
P. Barry  
J. Chihota  
T. R. C. Fernandes  
D. D. Katsande  
M. Lipalile  
A. Mutemererwa  
D. Mzengeza  
A. E. Roberts  
P. van Straaten (Canada)  
B. M. C. Tsomondo

**Department of Geology, Univ. of Zimbabwe**  
R. Owen

**Department of Chemistry, Univ. of Zimbabwe**  
Z.J. Duri  
R. Goredma  
E. G. Hove, Chairman  
D.N. Jumbam  
I. Love  
A. S. Mathuthu  
S. D. Sithole  
M. F. Zaranyika

**Main Library, Univ. of Zimbabwe**  
M. Chishanga and J.L. Maenzanize

## Annex 3

# Questionnaire to the Project Participants

PROJECT NAME:

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### I. Quantitative data (state monetary figures in 1000SEK or equiv.):

- A. Year project started \_\_\_\_\_
- B.
1. No. of graduate students enrolled in 96/97: Ph.D. \_\_\_\_\_  
M.Sc. \_\_\_\_\_.
  2. Total number of degrees awarded in the project: Ph.D. \_\_\_\_\_  
M.Sc. \_\_\_\_\_.
  3. No. of technicians trained \_\_\_\_\_.
  4. No. of investigators involved in the project \_\_\_\_\_.
- C.
1. No. of publications with Zimbabwean (co)authorship in refereed international journals \_\_\_\_\_, national journals \_\_\_\_\_, proceedings \_\_\_\_\_, others \_\_\_\_\_.
  2. Involvement in and support of relevant local activities in the form of training courses no. \_\_\_\_\_, seminars no. \_\_\_\_\_, written material no. \_\_\_\_\_ and other \_\_\_\_\_.
- D.
1. Establishment of facilities for laboratory and or field work (incl. vehicles), amount spent \_\_\_\_\_.
  2. Provision of literature: books, journals etc. amount spent \_\_\_\_\_.
- E.
1. Project funding: 96/97 \_\_\_\_\_ 94/96 \_\_\_\_\_, 92/94 \_\_\_\_\_, 90/92 \_\_\_\_\_, 88/90 \_\_\_\_\_.
  2. Funding from local sources including project related salaries; University, \_\_\_\_\_; Government \_\_\_\_\_; other \_\_\_\_\_.

3. Total funding for the last 5 years:

Outside sources: \_\_\_\_\_

Local sources: \_\_\_\_\_

**II. Qualitative information. Describe briefly:**

- A. The project and its goals (specific target(s), timeframe, etc.).
  
  
  
  
  
  
  
  
  
  
- B. Achievements including capacity building (institution building, human resources, infrastructure (buildings), equipment and other facilities).
  
  
  
  
  
  
  
  
  
  
- C. Research cooperation with other Zimbabwean and foreign researchers (including Swedish).
  
  
  
  
  
  
  
  
  
  
- D. Dissemination of research results to local users.
  
  
  
  
  
  
  
  
  
  
- E. How often the project is evaluated.

- F. Degree of utilization and maintenance of equipment.
- G. Major constraints in the project.
- H. Alternative funding sources in case SAREC withdraws.
- I. Main incentives for participating in the project.



## Annex 4.

### Publication Lists for the Four Projects

Annex 4 contains lists of publications in scientific books and journals which have resulted from SAREC sponsored research within the four projects. The extensive list from the Chromite Mining Project contains some publications which are based on research which only marginally benefitted from SAREC support. Note that many of the reports in the list have limited availability; they have been included because these are typical for the research dissemination that takes place within the Chromite Mining Project.

Note also that the numerous conference presentations have not been listed; nor are theses at the Masters and Doctoral levels included. The latter represent an important part of the research carried out in many projects. It must be stressed that much more information on the dissemination of research is available from the four individual projects; the following lists are primarily intended to give an impression of the publication practices used in the projects.

#### Annex 4.1: Publications from the Biotechnology Project

Adlercreutz, P., Gitlesen, T, Ncube, I, Read, J.S. (1996). "Vernonia lipase: a plant lipase with strong fatty acid selectivity. *Methods of Enzymology*" (Invited for publication).

Afolabi O.A., Olugunde M.O., Anderson W.A., Read J.S., Dacosta M.D., Epps F.A., and Ayorinde F.O. (1991). "The use of lipase (acetone powder) from *Vernonia galamensis* in fatty acid analysis of seed oils". *Journal of Chemical Technology and Biotechnology*, 51,41-46.

Bulawayo B., Bvochora J.M., Muzondo M.I., and Zvauya R. (1996). "Ethanol production by fermentation of sweet-stem sorghum juice using various yeast strains". *World Journal of Microbiology & Biotechnology*, 12,357-360.

Benhura M.A.N., and Marume M. (1993). "Degradation of mucilagenous polysaccharide (*Dicerocaryum zanguebarium*) during autoclaving". *Carbohydrate Polymers*, 21,13-16.

Benhura M.A.N., and Marume M. (1993). "Emulsifying properties of a mucilage extracted from ruredzo (*Dicerocaryum zanguebarium*)". *Bioscience, Biotechnology and Biochemistry*, 57,1993-1995.

Benhura M.A.N., and Marume M. (1993). "The mucilagenous polysaccharide material isolated from ruredzo (*Dicerocaryum zanguebarium*)". *Food Chemistry*, 46,7-11.

- Benhura M.A.N., and Marume M. (1994). "Viscosity behaviour of the mucilage extracted from ruredzo (*Dicerocaryum zanguebarium*)". *Starke/Starch*, 46,106-108.
- Benhura M.A.N., and Marume M. (1994). "Periodate oxidation of the mucilage from ruredzo (*Dicerocaryum zanguebarium*)". *Chemie Mikrobiologie Technologie der Lebensmittel*, 16,65-68.
- Benhura M.A.N., Mushuku T.J. and Mutenda E.K. (1994). "Action of carbohydrate degrading enzymes on the mucilage extracted from ruredzo (*Dicerocaryum zanguebarium*)". *Chemie Mikrobiologie Technologie der Lebensmittel*, 16, 39-43.
- Benhura M.A.N. and Mavhudzi I. (1996). "Use of crosslinked mucilage prepared from ru redzo (*Dicerocaryom zanguebarium*) in the purification of polygalacturonase extracted from tomato". *Food Chemistry*, 56, (in press).
- Benhura M.A.N. and Mavhudzi I. (1996). "Preparation of water insoluble crosslinked mucilage from ruredzo (*Dicerocaryum zanguebarium*)". *Starke/Starch* (submitted).
- Kaul R., Read J.S., and Mattiason B. (1991). "Screening for plant lectins by latex agglutination tests". *Phytochemistry*. 30,4005-4009.
- Kaul, R., Guoiquiang D., Lali, A., Benhura, M.A.N., and Mattiasson, B. (1994). "Affinity isolation of proteins based on precipitation of eudragit-ligand protein complexes". *Separations for Biotechnology*, 3,243-248.
- Mawadza C. and Zvauya, R. (1996). "Some factors affecting endo-B-1,4-glucanase production by two *Bacillus* strains isolated from Zimbabwean hot springs". *Journal of Basic Microbiology*, 3,177-185.
- Mawadza C., Boogerd F.C, Zvauya R., and van Verseveld H.W. (1996). "Influence of environmental factors on endo-B-1,4-glucanase production by *Bacillus* HR68, isolated from a Zimbabwean hot spring". *Antonie van Leeuwenhoek* (in press).
- Mushuku T., Benhura M.A.N., Kaul R., Earson M., and Mattiasson B. (1993). "Aqueous two phase systems for molecular weight analysis". *Biotechnology Techniques*, 7, 249-259.
- Ncube I., Adlercreutz P., Read J.S., and Mattiasson B. (1993). "Purification of rape (*Brassica napus*) seedling lipase and it use in organic solvents". *Biotechnology and Applied Biochemistry*, 17,327-336.
- Ncube I., Chikunguwo S., and Read J.S. (1995). "A colorimetric method for the quantification of lipid and assaying lipase activity". (in preparation).
- Ncube I., Gitlesen T., Adlercruutz P., Read J.S., and Mattiasson B. (1995). "Fatty acid selectivity of a lipase purified *Vernonia galamensis* seed". *Biochemica et Biophysica Acta*, 1257,149-156.

- Ncube I. and Read J.S. (1995). "Evaluation of *Vernonia galamensis* lipase (acetone powder) for use in biotechnology". *Industrial Crops and Products*, 3,285-292.
- Pontamianos S., Chikunguwo S., Read J.S., and Mason P.R. (1992). "Lysis of Erythrocytes by *Trichomonas vaginalis*." *Bioscience Reports*, 12,387-395.
- Zvauya R., and Muzondo M.I. (1993). "Protein enrichment of cassava by solid state fermentation". *Chemie Mikrobiologie Technologie der Lebensmittel*, 15,171-174.
- Zvauya R., and Dawson J.L. (1994). "Electrochemical reduction of carbon dioxide and the effect of the enzyme carbonic anhydrase 11 on iron corrosion". *Journal of Chemical Technology and Biotechnology*, 61,319-324.
- Zvauya R., and Muzondo M.I. (1994). "Some factors affecting protein enrichment of cassava flour by solid state fermentation". *Lebensmittel-Wissenschaft und-Technologie*, 27,590-591.
- Zvauya R., Parawira W., and Mawadza C. (1994). "Aspects of aerobic thermophilic opaque beer brewery wastewater". *Bioresource Technology*, 48,273-275.
- Zvauya R., Mugochi T., and Parawira W. (1995). "Microbial and biochemical changes occurring during production of znassussu, a traditional non-alcoholic Zimbabwean beverage". *Journal of Plant Foods for Human Nutrition* (resubmitted).
- Zvauya R., and Muzondo M.I. (1995). "Reduction in cyanide levels in cassava during sequential sundrying and solid state fermentation". *International Journal of Food Science and Nutrition*, 46,13-16.
- Zvauya R. and Zvidzai C.J. (1995). "Constitutive production of endoglucanase by a *Bacillus* sp. isolated from a Zimbabwean hot spring". *World Journal of Microbiology & Biotechnology*, 11,658-660.
- Zvauya R. and Zvidzai C.J. (1996). "Production of hydrolytic enzymes by a *Bacillus* sp. grown on opaque beer brewery wastewater supplemented with spent yeast and deffated soya waste". *Advances in Food Science*, 18,12-17.

## **Annex 4.2 Publications from the Chromite Mining and Ferrochrome Smelting Project**

- Chihota, J.S.; Zulu, E. (1995) Simulation of pollutant transport in rivers Maponga, O.P. *comp.* The environmental impacts of mining in Zimbabwe...1st Interim Rep. (Inst. Min. Res., Univ. Zim. Confid. Rep. C670), p.6-10
- Chihota, J.S. (1996) Lead in the environment -- a brief literature review Inst. Min. Res., Univ. Zim. 27th Ann. Rep. for the year 1995 (Rep. 159), p.40-41

- Chiwawa, H. (1991) Chromite mining cooperatives in Zimbabwe Inst. Min. Res., Univ. Zim. 22nd Ann. Rep. [for 1990] (Rep. 127), p.156-157
- Chiwawa, H. (1991) Co-operative chromite mining in Zimbabwe Fernandes, T.R.C. ed. *Report of the Third UNESCO Regional Training Programme in MiningGeology*, 16 July-21 September 1990, Harare, Zimbabwe. Harare : Institute of MiningResearch for UNESCO Regional Office for Science and Technology for Africa, p.44-45
- Ericsson, M.; Mutemererwa, A.M. (1992) Mineral economics of chromite mining and ferrochromium smelting Inst. Min. Res., Univ. Zim. Confid. Rep. C553, 56p.
- Ericsson, M.; Mutemererwa, A.M. (1993) Demand and supply analysis of chromium : a SAREC sponsored project Inst. Min. Res., Univ. Zim. 24th Ann. Rep. [for 1992] (Rep. 146), p.81-110
- Fernandes, T.R.C. (1992) Structural characterization of two types of chromium spinel from the Great Dyke, Zimbabwe Inst. Min. Res., Univ. Zim. Rep. 139, 10p.
- Fernandes, T.R.C. (1992) Structural characterisation of chromium spinels Inst. Min. Res., Univ. Zim. 23rd Ann. Rep. [for 1991] (Rep. 136), p.29-34
- Fernandes, T.R.C. comp. (1993) Development of chromite mining and ferrochrome smelting in Zimbabwe : SAREC funded project. Second interim report, August 1990 to June 1992 Inst. Min. Res., Univ. Zim. Confid. Rep. C566, 101p.
- Fernandes, T.R.C. (1993) Measurements of magnetic properties of chromites Inst. Min. Res., Univ. Zim. 24th Ann. Rep. [for 1992] (Rep. 146), p.20-27
- Fernandes, T.R.C. (1994) Mineralogy of chromites from Zimbabwe : progress report for 1993 Inst. Min. Res., Univ. Zim. Confid. Rep. C625, 14p.
- Fernandes, T.R.C. (1994) Mineralogy of chromites from Zimbabwe. Progress report for 1994 Inst. Min. Res., Univ. Zim. Confid. Rep. C646, 25p. Mutemererwa, A.M. comp. SAREC funded project : The development of chromite mining and ferrochrome smelting in Zimbabwe. 5th Interim Rep. (Inst. Min. Res. Confid. Rep. C666), p.1-25 *Summary in:* Inst. Min. Res. 26th Ann. Rep. (Rep. 156), p.53-67
- Fernandes, T.R.C. (1994) X-ray diffraction analysis of chromites Inst. Min. Res., Univ. Zim. 25th Ann. Rep. for the year 1993 (Rep. 151), p.20-23
- Fernandes, T.R.C. (1994) Studies of the magnetic properties of chromite Inst. Min. Res., Univ. Zim. 25th Ann. Rep. for the year 1993 (Rep. 151), p.24-27
- Fernandes, T.R.C.; Lee, W.E.; Mitchell, T.E. (1994) Microstructural aspects of reduction of Zimbabwe chromite to high-carbon ferrochromium Trans. Inst. Min. Metall. C, v.103, p.C177-C187
- Fernandes, T.R.C. (1996) Mineralogical studies of chromites from Zimbabwe Inst. Min. Res., Univ. Zim. 27th Ann. Rep. for the year 1995 (Rep. 159), p.46-50

Hanssen, M.G.; Roberts, A.E.; Musanhu, R.; Mangwaira, O.; Turner, G.; Pei, W.; Chiwawa, H.; Agren, A.; Ericsson, M.; Mutemmerwa, A.M. (1990) SAREC funded project. The development of chromite mining and ferrochrome smelting in Zimbabwe : interim report Inst. Min. Res., Univ. Zim. Confid. Rep. C476, [151] maps

Hanssen, M.G. (1991) Geology of no.2 and no.4 seams of the Great Dyke Inst. Min. Res., Univ. Zim. 22nd Ann. Rep. [for 1990] (Rep. 127), p.58-61

Hanssen, M.G. (1991) Geology of the Great Dyke of Zimbabwe Fernandes, T.R.C. *ed.* Report of the Third UNESCO Regional Training Programme in Mining Geology, 16 July-21 September 1990, Harare, Zimbabwe. Harare : Institute of Mining Research for UNESCO Regional Office for Science and Technology for Africa, p.41-43

Jourdan, P.; Maponga, O.P. (1989) Minerals sector of Namibia : post-independence strategies Inst. Min. Res., Univ. Zim. Rep. 96, 19p.

Jourdan, P.; Maponga, O.P.; Manyenya, S. (1989) Analysis of ad hoc foreign currency allocations to exporting mines under the ERF scheme by product group (code) and product for the period 2/1987 to 2/1988 Inst. Min. Res., Univ. Zim. Confid. Rep. C460, [60]p.

Jourdan, P.; Maponga, O.P.; Manyenya, S. (1989) Analysis of ad hoc foreign currency allocations to non-exporting mines under the MCR scheme by product group (code) and product for the period 1985 to 1988 (excluding 1987) Inst. Min. Res., Univ. Zim. Confid. Rep. C461, [60]p.

Jourdan, P. (1989) Substitution of South African exports of ferrochrome and PGM's by increasing Zimbabwean production : estimated costs Inst. Min. Res., Univ. Zim. Confid. Rep. C463, 11p.

Jourdan, P.; Maponga, O.P.; Manyenya, S.; Ncube, M.; Makuni, P. (1989) Analysis of foreign currency allocations to the mining sector in Zimbabwe for the period 1985 to 1988 Inst. Min. Res., Univ. Zim. Confid. Rep. C482

Jourdan, P. (1989) Problems and prospects of the mining sector of the S.A.D.C.C. Inst. Min. Res., Univ. Zim. Rep. 109, 38p., maps Extracts in: Inst. Min. Res., Univ. Zim. 21st Ann. Rep. (Rep. 102), p.85-93

Jourdan, P. (1989) Regional strategies for the mining and mineral processing industries of the states of the SADCC Inst. Min. Res., Univ. Zim. 20th Ann. Rep. [for 1988] (Rep. 77), p.157-167

Jourdan, P.; Maponga, O.P.; Manyenya, S.; Ncube, M.; Makuni, P. (1989) Import substitution and the mining sector of Zimbabwe Inst. Min. Res., Univ. Zim. 20th Ann. Rep. [for 1988] (Rep. 77), p.168-181

Jourdan, P. (1990) Minerals industry of Swaziland : A SAREC funded project Inst. Min. Res., Univ. Zim. Rep. 104, 16p.

- Jourdan, P. (1990) Minerals industry of Malawi : a SAREC funded project Inst. Min. Res., Univ. Zim. Rep. 105, 16p.
- Jourdan, P. (1990) Minerals industry of Botswana : a SAREC funded project Inst. Min. Res., Univ. Zim. Rep. 106, 23p.
- Jourdan, P. (1990) Minerals industry of Zimbabwe Inst. Min. Res., Univ. Zim. Rep. 107, 27p.
- Jourdan, P. (1990) Minerals industry of Namibia Inst. Min. Res., Univ. Zim. Rep. 115, 10p.
- Jourdan, P. (1990) Minerals industry of Angola Inst. Min. Res., Univ. Zim. Rep. 116, 16p.
- Jourdan, P. (1990) Minerals industry of Lesotho Inst. Min. Res., Univ. Zim. Rep. 118, 3p.
- Jourdan, P. (1990) Minerals industry of Tanzania Inst. Min. Res., Univ. Zim. Rep. 119, 17p.
- Jourdan, P. (1990) Minerals industry of Zambia Inst. Min. Res., Univ. Zim. Rep. 120, 26p.
- Jourdan, P. (1990) Consolidated bibliography for IMR reports on the minerals industries of the states of the SADCC Inst. Min. Res., Univ. Zim. Rep. 122, 18p.
- Jourdan, P. (1990) Minerals industry of the SADCC region Inst. Min. Res., Univ. Zim. Rep. 126, 13p. Inst. Min. Res. 22nd Ann. Rep. (Rep. 127), p.114-126
- Jourdan, P. (1990) SADCC Mining Coordination Unit Inst. Min. Res., Univ. Zim. Rep. 129, 7p.
- Jourdan, P. (1991) Regional strategies for the minerals industries of the states of the SADCC African Mining '91. London : Elsevier for the IMM, p.347-353
- Jourdan, P.; Maponga, O.P.; Mutemererwa, A.M. (1991) Analysis of forex allocations to the mining industry 1986-1990 Inst. Min. Res., Univ. Zim. Rep. 128, 8p. Inst. Min. Res., Univ. Zim. 22nd Ann. Rep. (Rep. 127), p.170-177
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