

EARTH OBSERVATION KNOWLEDGE TRANSFER: THE EXAMPLE OF ITC'S COAL FIRE PROJECT

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ABSTRACT:

For over 50 years, the ITC has practiced knowledge transfer of geoinformation and earth observation technology and applications by means of education and training, joint applied research, and in the form of institutional support projects. This paper describes the methods and results of earth observation knowledge transfer for ITC's project on the detection, measurement, monitoring and management of underground coal fires.

The following phases of the knowledge transfer process are described in this paper:

- Knowledge transfer inside ITC, to tap the expertise in the different departments, and to build up the research team.
- Knowledge transfer inside the Netherlands, to access expertise not available within ITC, but required to solve the problem. This is done through ITC's network of Dutch Universities, research institutes and private sector.
- Knowledge transfer internationally, from experts in other countries with similar problems, or with expertise in tackling the problem, as well as knowledge transfer within the recipient partner organizations in the developing country.
- Education and training of researchers, professionals, managers, etc., at all levels, from short management workshops/seminars to MSc and PhD studies, as well as Post Doctoral and visiting scholar schemes.
- Publication and promotion of the results via scientific papers in refereed journals, at international conferences, in professional and popular magazines and newsletters, as well as via the media, in terms of local, national, and international newspapers, radio and TV-interviews, and TV-documentaries.

The above phases and activities then result in additional funding from other donors, and as the remote sensing research results in more and more practical benefits, a critical mass of expertise is built up in the country to ensure the knowledge transfer is sustainable in the long term. Furthermore, this knowledge transfer approach of applied earth observation also results in many spin-off benefits to other applications and transfer of the developed methodologies to other important problems in developing countries. The paper is illustrated by ITC's 15 year coal fire project in China.

1. INTRODUCTION

1.1 The problem of coal fires

Underground coal fires occur in many countries of the world (USA, Australia, Germany, Spain, Poland, Czech Republic, India, Pakistan, Indonesia, Venezuela, China, etc.) and cause serious environmental damage (Genderen, J.L. van and Guan, H.Y., 1997). Among the environmental hazards produced by coal fires are:

- Loss of coal resources and loss of mining productivity:** In China it is estimated that 100 to 200 million tons of high quality coal are lost every year! (Genderen, 1999). This amounts to 5 to 10 times total coal exports from China, the world's largest producer and exporter of coal (China Statistical Year Book, 1993).
- Very high CO₂ emission:** The CO₂ emission of the Chinese coal fires is estimated at 1% of the total CO₂ production by combustion of fossil fuels in the world. This emission is approximately 2 times as high as the total annual production of CO₂ in the Netherlands (Rosema et al., 1995).
- Very high air pollution:** Besides the high contribution to the greenhouse effect of CO₂, many other harmful pollutant gases are released by the coal fires such as CO, SO₂, CH₄, H₂S, N₂¹⁰, etc.
- Degradation of the environment:** The burnt-out coal layers cause subsidence, landslides, rock falls, etc. causing extensive physical and economic damage to infrastructure

(roads, railways, power lines, settlements, other engineering structures) and to vegetation (forest fires) and soil quality degradation.

- Safety and health risk for the miners and population:** Many miners are working under dangerous conditions and many lives are lost each year as a result of the coal fires.

Coal is the most important source of energy in the People's Republic of China (PRC). China is the largest producer and exporter of coal in the world. Where coal layers reach the surface they are in contact with oxygen and prone to oxidation. Particularly in mining areas situated in arid and semi-arid regions, exploitation creates conditions which favour spontaneous combustion in coal litter. All over northern China there are a large number of coal fires, which cause an estimated yearly coal loss of between 100 and 200 million tons.

1.2 The role of earth observation

The extent of the area affected by coal fires in China is very large, stretching 5.000 km from W to E and 500 km from N to S (see figure 1). It is almost impossible to obtain an overview of the coal fire problem in such a large area by conventional means. Satellite and airborne remote sensing data are essential to provide this overview (Zhang et al., 2003). Repeated observations introduce a time dimension, thus allowing to monitor the development and spread of coal fires as well as the success of coal fire fighting measures. The introduction of the satellite information and other spatial data in a Geographic Information System (GIS), facilitates the accessibility and easy

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assessment of the data by the end users, mainly the coal mine managers, provincial fire-fighting teams, and decision makers at local, regional and national level (Rosema et al., 2000).



2. KNOWLEDGE TRANSFER

2.1 Knowledge transfer inside ITC

Professor van Genderen started his research on coal fires in China in 1987, first on a small scale, but as of the 1990's, started to tap the expertise in other ITC scientific departments. By presenting the work being done at internal research seminars and newsletters, many more staff became involved and have contributed enormously to the development of remote sensing and GIS technology for detecting, measuring, modelling, monitoring and predicting the location, depth, size, etc. of coal fires in China as well as in several other affected countries such as India, Indonesia, Venezuela, etc. (Zhang et al., 1997). More than 10 ITC staff members have been actively involved in the coal fire research project. The main ones have been van Genderen, van Dijk, Koopmans, Prakash, Vekerdy, van der Meer, Maathuis, Sharif, Tian, Hecker and van Westen.

2.2 Knowledge transfer inside the Netherlands

In order to acquire expertise and resources not available inside ITC, the Institute involved many other Dutch researchers and private companies. By transferring ITC's experience to them, they could quickly contribute their skills and thus provided "value-adding" to the end users in China. Organizations involved in the Netherlands included the Netherlands Geological Survey (RGD), now re-named TNO-Netherlands Institute for Technical Geosciences, the University of Delft, University of Utrecht, EARS BV, and GEOSAT (Rosema et al., 1999; Zhang et al., 2003; Rengers F. van Weelderden, 1996). Copies of ITC's research, publications, technical reports, MSc and PHD theses, etc. were provided to these partners.

2.3 Knowledge transfer inside Europe

As the technical, scientific and organizational/institutional/management issues became increasingly complex, the ITC involved many other European centres of excellence and organizations with skills relevant to tackling the problems described in 1.1 above. These included the thermal I.R. expertise of the Russian Academy of Science in St. Petersburg, Russia, the University of Dundee, Scotland and the University

of Freiburg in Germany; the satellite image mapping expertise of SSC Satellitbild (now METRIA) in Sweden, the coal mining expertise of DMT in Essen, Germany, as well as several other German organizations who are now continuing with new coal fire monitoring project in China, such as the DLR, BGR, BAM, GSF and some universities. All of ITC's many publications, reports, theses etc. were transferred to these organizations to assist them in their tasks (Cracknell, et al., 1994; Genderen J.L. van, 1996).

2.4 Knowledge transfer to P.R. China

Here the knowledge transfer process consisted of training Chinese researchers, coal fire fighters, coal-ministry managers at provincial and national levels. The training took the form of scientific research supervision (MSc, PhD, visiting scholars, Post-Doc researchers), on-the-job training in the field, on-site workshops, seminars and short training courses, developing and transferring the coal fire fighting plans and associated hardware and RS/GIS software to the on-site agencies responsible for managing the coal fires (Zhang et al., 1999; Vekerdy, Z. and Genderen, J.L. van, 1999). The main Chinese organizations involved are listed in Table 1.

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| <ul style="list-style-type: none"> • Airborne Remote Sensing Corporation of Chinese Coal (ARSC) • Beijing Remote Sensing Corporation (part of Shenhua Group) • Xi'an University of Science and Technology • China National Administration of Coal Geology • China Geological Survey • Research Inst. for Coal Geophysical Exploration • National Remote Sensing Center of China • China Coal Research Institute • Provincial Bureau's of coal industry in Xinjiang, Gansu, Ningxia, Shaanxi, Inner Mongolia and Shanxi • Fire Fighting Teams in Xinjiang and Ningxia autonomous regions |
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Over the past 15 years, the cooperation with the Chinese partners had gradually changed from one in which know-how, hardware and software was transferred to Chinese partners, to a relationship as equal research partners. The progress in China's earth observation capabilities and know-how has been truly spectacular over this period (Guo, H.D., 2003).

3. EDUCATION AND TRAINING

As a key component in this long term research project was to build up local capacity, much emphasis has been given to education and training. Ten Chinese workers have completed an MSc degree at ITC on various aspects of earth observation applied to the detection, measurement and monitoring of underground coal fires (e.g. Zhang, J.Z., 1996; Prasun, K.G., 2002). Five researchers have obtained PhD degrees on this topic (e.g. Cassells, C.J.S., 1997). In addition, three Post Doctoral researchers and six visiting scholars have spent a year at ITC working with the ITC team. In addition, many on-the-job training courses, on-site workshops and seminars have been held throughout the effected provinces and autonomous regions in China's north-west, north and north-east.

4. PUBLICATIONS AND PROMOTION OF RESULTS

4.1 Publications

Publications are of course, a major way to transfer technology in a scientific manner. To date, the ITC coal fire projects in China have resulted in more than 20 scientific papers in internationally refereed journals. The prestigious International Journal of Remote Sensing has published ten research papers by the ITC Team members. Other international journals where coal fire papers have been published by ITC staff include: Asian-Pacific Remote Sensing and GIS Journal, Journal of Coal, Geologie and Mijnbouw, Terra Nova, etc.

Over forty conference papers have been presented on ITC's earth observation research applied to coal fire research in China by the team members. This has helped to disseminate knowledge on the seriousness of this problem, stimulate discussion on new techniques and methods, and, perhaps most importantly, has encouraged many other researchers worldwide to become motivated to study this problem more deeply. Conferences to disseminate ITC's research approach have been attended in Australia, Austria, United Kingdom, China, U.S.A., the Netherlands, Iran, India, Canada and Germany.

Besides scientific publications in refereed journals and in conference proceedings, numerous technical reports, monographs and manuals have been produced as part of the transfer of technology process. These include reports such as:

1. Environmental Monitoring of Coal Fires in North China (BCRS Report 1993)
2. Monitoring and Management of Fragile Ecosystems in Shanxi, Shaanxi and Inner Mongolia (ADB Report, 1994)
3. Environmental Monitoring of Spontaneous combustion in the North China Coal Fields (EU Report)
4. Manual of Coal Fire Detection and Monitoring (NITG)
5. Manual of Coal Fire Fighting and Prevention Plan (NITG)
6. Coal Fire Interferometry (BCRS Report).

A further form of publication, which has been very successful as part of spreading the results of the coal fire research and projects using earth observation has been that of posters. More than 20 A0 size posters, richly illustrated with imagery, schematics, text, diagrams, etc. on many detailed aspects of the coal fire problem have been produced. These have been awarded "Best Poster" paper at various international conferences in North America and Europe. The posters also serve as a useful tool to attract the media, and thus further promote attention to this serious environmental problem.

4.2 Promotion

Giving publicity to achieved research results is becoming increasingly important to draw attention to the role of earth observation for solving practical, real-world problems. ITC's coal fire research has been very successful in this regard. Table 2 lists a few of the popular scientific magazines and newsletters that have written articles about the coal fires projects in China. Mostly they are lavishly illustrated, as still many people have never seen a naturally occurring (or man-induced one) coal fire and the dramatic landscapes which result.

Table 2: Popular Scientific Magazines and Newsletters featuring articles on ITC's coal fire projects.

- 1) World Coal (U.K., 08/2002)
- 2) China National Geographic (China, 10/2000)
- 3) EARSel Newsletter (France, 1998)
- 4) De Ingenieur (the Netherlands, 07/1997)
- 5) The Sciences (USA)
- 6) EOS (USA, 11/1997)

- 7) KJJK Magazine (the Netherlands, 08/1995)
- 8) Readers Digest (USA, 02/2004)
- 9) GEO Magazine
- 10) New Scientist, 02/2003
- 11) Geotimes, 11/2002
- 12) Der Spiegel (Germany, 10/1999)
- 13) Greenpeace Magazine, 02/2002

The popular press has also shown great interest in this ITC research and the newspaper articles have in turn drawn the attention of decision makers and funding agencies as well as creating private sector interest in this issue. Some examples of the (inter)national press that has devoted, often front page articles to this work include: The Times, Financial Times and The Daily Telegraph (United Kingdom), Le Figaro (France), China Daily, China Coal News, Science and Technology Daily, China Economic Herald, Science Times (all from China). The New York Times (USA), Berliner Zeitung, Welt am Sonntag, Neue Züricher Zeitung (Germany). In addition to almost all Dutch National Newspapers having carried stories about ITC's coal fire research (e.g. Trouw, de Volkskrant, NRC Handelsblad), many regional and local newspapers have done likewise (Twentse Courant Tubantia, Utrecht's Nieuwsblad, Haagse Courant, etc.).

Radio interviews in China and in various European countries coupled with TV coverage, have further helped to draw attention to the coal fire problem, with the purpose of obtaining more political, financial and scientific support. Dutch National TV produced an English and Dutch half hour documentary film on this topic entitled "The Hidden Fire" (VPRO Het Noorderlicht). This has been shown in various countries and on National Geographic TV. The Chinese National TV (CCTV) has also made several TV programmes and interviews on ITC's coal fire project). In addition, radio interviews on BBC News and Dutch World Service Radio have been given.

5. CONCLUSIONS

For more than 15 years, ITC and its Chinese and other (inter)national partners have been carrying out research into the problem of detecting, measuring, modelling, monitoring and extinguishing coal fires by using Earth observation techniques coupled with field and laboratory investigations and using GIS. By paying particular attention to the knowledge transfer process by means of education and training, publications and promotional activities, several benefits have resulted. These includes:

- A critical mass of well-trained Chinese scientists, technicians, administrators and managers, ensuring long-term sustainability and an indigenous capability to carry on with this work.
- The many scientific and technical publications produced by the ITC team members has drawn this problem to the attention of the international scientific community. This has resulted, amongst others, in German research groups under coordination of the DLR now being actively involved in a large, multi-year, multi-disciplinary research project on coal fires in North China. In the USA, the spontaneous combustion of coal is once again a topic receiving a considerable attention, as witnessed by the new series of conferences and meetings on this topic in the USA, such as the GSA Wild Coal Fire Meeting to be held later this year, which will also publish a special book on coal fires.
- Experience has shown that by starting small, with only one Chinese partner at the beginning of our research in the

1980's, first understanding the problem, the issues, the local constraints, etc. that one can then expand the research, publish results, carry out promotional activities. These in turn attract extra research funds, which in turn allows the project to tackle increasing complex scientific issues by means of more staff, equipment and other resources.

- The research into coal fires using earth observation has resulted in spin-off to other applications in Developing countries. The techniques of thermal IR interpretation, SAR interferometry, image and data fusion, multi stage sampling (from simultaneously acquired satellite, aircraft, ground and subsurface data) have been also successfully applied to other problems such as sub-surface detection of landmines, land subsidence, environmental monitoring, etc. (Gens, R. and Genderen, J.L. van, 1996; Pohl C., and Genderen, J.L. van, 1998; Maathuis, B.H.P., and Genderen, J.L. van., 2004)

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