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# COAL HERITAGE FROM SOUTHERN BELGIUM: A PRESERVATION AND COMPUTERIZED MANAGEMENT OF COAL CONCESSIONS DATA

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A b s t r a c t . From the past centuries until the seventies, underground coal mining activities have played an important role in the suburban development of western European coal basins. After closure of collieries, the impact of this activity on a fast growing urban environment is still obvious and cannot be underestimated. Changes in hydrological regime, water and soil pollution, sudden collapse or ground instability are risk factors not to be minimized. Old mining and related industrial sites have now to be revalidated and underground infrastructures and city planners and local authorities cannot ignore mineshafts. This is only possible if the huge amount of available mining data is preserved and their information computerized. These mining data represent an essential component of urban geology that must be integrated in an easy access geographic information system. The old coal districts in southern Belgium serves as a case study for developing an appropriate methodology.

K e y w o r d s : coal mines, mining data, urban environment, information system, Belgium.

## INTRODUCTION

The development of major cities and their suburbs reinforces the need for an integration of all environmental factors. Amongst them, geology is not always evaluated as it should be. Periodically, underground failure or collapse in urbanized areas are making headlines, calling city-planners attention to geological aspects. Considerable efforts are made to convince local authorities, Mayors and town-planners of the necessity to better take into account geological factors for sustainable development of the cities of tomorrow. The localization of underground quarries and old mines underneath urbanized areas is a particular aspect with strong environmental impact. Related problems are diverse: spectacular ground collapses, subsiding areas, failures of foundations, aquifers pollution etc. In such a context, all the available data (historical, geological etc.) on underground exploitations must be integrated in the urban geological database. Gathering these data which are scattered is an important aspect, time-consuming, but valuable. Encoding and computerizing must be done in a second phase that valorises considerably the data. The finality is that non-professional can have an easy access to a relational database, connected to a Geographical Information System (GIS). This integrated system will serve efficiently city-planners, only if the database is as complete as possible.

The present paper deals mainly with the coal-mining district of southern Belgium, which has to face major problems of post-industrial site revalidation and data management. The Geological Survey of Belgium (GSB) has developed a specific methodology to face this problems and to manage efficiently the huge amount of available coal mining data. This work, developed by the GSB, is part of a larger project dealing with other aspects of urban geology (GEOINDEC project for GEOlogical INtegrated Database for Environment and Cities).

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## GEOLOGICAL CONTEXT

Economical coal resources of Belgium are restricted to the Upper Carboniferous Westphalian Coal Measures. A flysh sedimentation took place in paralic basins, in the context of the Variscan Rhenohercynian fold and thrust belt. Extensive coal mining activities were located in the Campine Basin and in the Namur Synclinorium, extending respectively at the northeastern and southern flanks of the Brabant Caledonian Massif (Fig. 1). The Namur Synclinorium is connected westwards to the Nord–Pas-de-Calais Basin of northern France forming the Franco-Belgian coal basin (Delmer, 1985). Middle Age activities are obvious but industrial extraction started only during the eighteenth century when technical progress made possible the lowering of the water table for several hundreds of meters.

Unfavourable economical and geological factors led to the closure of the last coal mine (the "Roton" at Farciennes) in the Namur Synclinorium in 1984 and a few years later in the Campine Basin with the closure of the only active working site (Zolder) in 1992 (Deleuze *et al*., 1996). Three main geological elements explain easily the economic deficit of coal production in southern Belgium:

— the strong tectonic deformation of the coal-bearing strata included in the Variscan Front Zone; folding and faulting have considerably hampered extraction and have required expansive surveying campaigns;

— the thinness of the coal seems with an average thickness of about 0.6 m; in many places, extensive mining extended lower than 1000 m depth;

— drawdown of the water-table.

In addition, high manpower costs and the low price of exported coal from South Africa, South America and the former USSR made worse the profit of this industrial activity.

However, it cannot be denied that coal-mining activities have greatly contributed to the economic development of the concerned areas during the second half of the eighteen century until the nineteen fifties. In 1948, about 180,000 workers were employed in Belgian coal mines (Hirsoux, 1994). Downstream activities with mainly iron and steel industries were established in the same district and contributed to the development of a rather anarchic urbanization. Today, comparison of the concession map and the unemployment statistic map demonstrates the economic impact of the suspension of mining and related activities in this area. It was one of the elements for considering the western part of southern Belgium as an economically unfair zone in the context of the European Union and a target in a program of economical development.

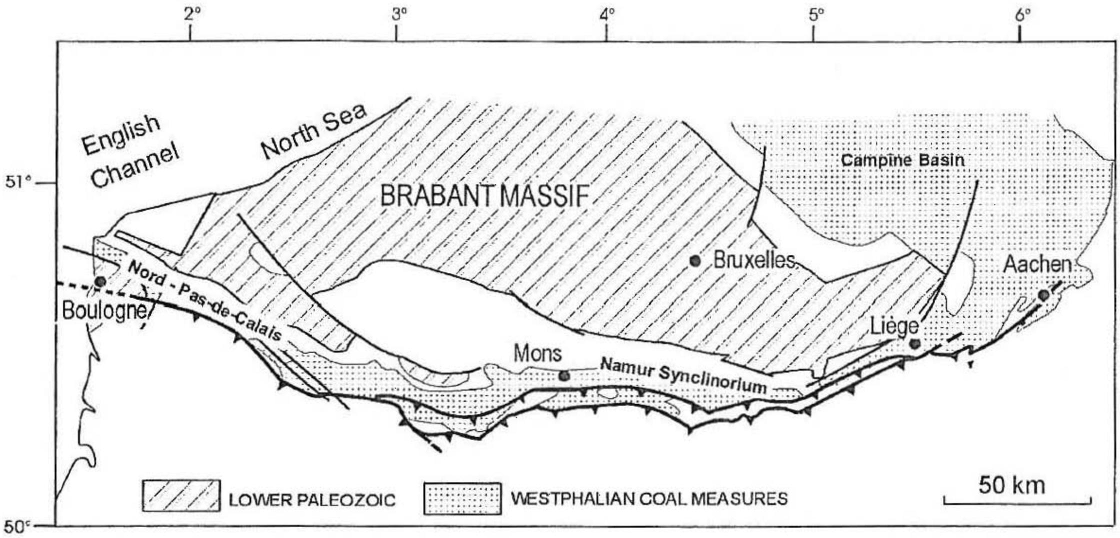


**Fig. 1. Location of the Westphalian Coal Measures, western Germany, Belgium and northern France**

## PRESENT DAY SITUATION AND RELATED PROBLEMS

The coal heritage is obvious on the field as the coal industry left its imprint on the landscape. Barren shales dump form slagheaps, up to 100 m high. Old surface infrastructures remain as witnesses of their glorious past. Derelict lands cover hundreds of hectares. Up to here, 1739 mineshafts have been indexed and localized within a limited zone (accuracy of 5 to 50 m). These shafts are unequally distributed with a high concentration in some communes. Moreover, very little is known about their cork or partial filling. Sudden collapse are an alarm bell revealing the existence of old shafts which have been forgotten for long time.

Stonedrifts, old foundations and other shallow depth infrastructures are also to be taken into account, for soil stability, security of infrastructures and foundations as well as for modifications of hydrological regime. Surface damages, related to the underground mining activities, have affected private and public infrastructures, houses and buildings. Locally, limited areas were subsiding for several meters and are now below the water table (Rorive, 1997) or have been subject to major flooding when located on riverbanks (Gaier, 1988). In the case of the Liège area, underground phosphatic chalk quarries record clearly the effects of deeper coal mining and their stability is worrying.

Development of new economical activities on disaffected mining sites and sustainable urbanization implies obviously to assume the coal heritage. Main cities like Mons, Charleroi and Liège and their suburbs are included in zones of intensive coal mining activities. It represents therefore one of the main aspects of their urban geological problems. Not only local authorities are concerned, but also regional and federal administrations, in the limits of their respective competencies.

Whatever is the authority level, the easy access to an integrated database is certainly a crucial point. Delivery of construction permits in a zone of closely spaced mine shafts is a risk. Revalidation of post-industrial sites makes also necessary to consult carefully all the available data concerning the underground. These data are of different types: historical documents, geological maps and cross-sections, mine concession and exploitation plans, shaft and stonedrift sections, plans of infrastructure. The evaluation of the data amount concerning coal-mining documents is not easy as no inventory exists and documents are kept in different places. Five years ago, the GSB started developing a specific computerized database, connected to a GIS, in order to provide a more easy management and consultation of the huge amount of existing data. The methodology adopted by the GSB and the main problems encountered are exposed hereafter.

## SCOPE AND GUIDE-LINES OF THE PROJECT

The historical and geological data of the coal mining industry in Belgium have to be preserved for several reasons:

— they represent a national heritage and knowledge resulting from more than 2 centuries of mining activities;

— outcrops are scarce; all further geological research on the coal measures (sedimentary history and sequence stratigraphy, structural context etc.) will necessarily be based on underground data.;

— underground gasification and underground gas storage projects are still under discussion;

— post-industrial revalidation of mining sites and urbanization will necessary to better take into account the past underground activities.

In the peculiar case of southern Belgium, the latter point appears essential. Hence, coal mining data should be integrated in an urban geological database, giving more weight and priority to shallow depth informations, location of wells and surface installations, i.e. all documents which are relevant for environmental impact and urban development.

## AVAILABLE DOCUMENTS

The source document corresponds to the last official map of coal concessions, established by the Mine Administration in 1946, at scale 1:40,000. The administrative situation of the concessions at that time serves as reference for the database (Fig. 2). However, it has been necessary to integrate data on the history of concessions before 1946. This step was time-consuming, but essential for encoding old documents. During coal exploitation, many small concessions get together to form biggest collieries, names have changed and overlapping of concessions in depth is frequent in the western part of the Coal Basin. The database gives access to the previous names of a particular concession and their historically bounded concessions.

Different kinds of documents are available for each concession:

**Exploitation plans in horizontal projection**. These plans were controlled by the Mine Administration and hence, can be considered as official documents. At scale 1:1000, they provide detailed information and permit to follow the history of the exploitation for each coal seam. They localize precisely the concession limits, the exploited areas and the mining structures: wells, stonedrifts, gateroads, longwall faces. Geological elements (faults, folds, natural wells, and thickness of the coal veins and grips) are also reported. Mining coordinates refer to the belfry of Mons. They have been converted into Belgian Lambert coordinates 72/50. About 25.000 of such plans in A0 format are deposited at the GSB, covering most of the southern Belgium coal district. Numerous plans are also stored in local mine museums, small associations of old miners etc.

**Exploitation plans in vertical projection**. They correspond to cross-sections passing through one or several mineshafts. At scale 1:1000, they permit to better understand: the structure of the coal exploitation and detailed informations about depth and geological composition of the stonedrifts. These plans permit to draw the tectonic structures of the coal measure.

**Wells sections**. These documents, at scale 1:100, give more geological information on the nature and thickness of barren cover, the stratigraphic succession, coal seams composition and designation, faults location. Connections with stonedrifts are given.

**Stonedrifts sections**. They correspond to the main galleries connected to the wells and roughly perpendicular to the geological strike.

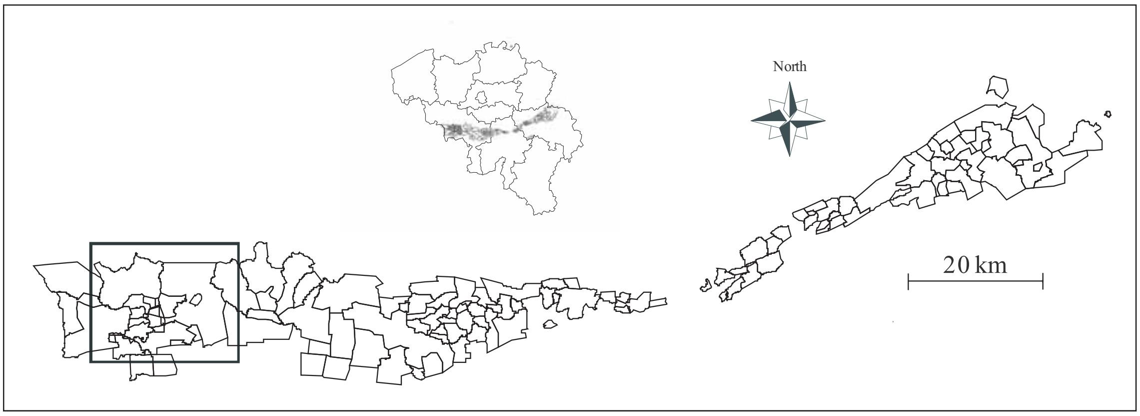


**Fig. 2. Vectorized limits of coal concessions in the southern part of Belgium. The black square indicates the Mons City area that serves as a "test area" for the Geoindec project. In 1946, 114 coal concessions were known in the southern part of the Belgian coal basin**

**Plans of surface mining installations**. At scale 1:100, these plans give the exact location of surface installations including air entry, air exit, extraction wells and extraction buildings.

In addition to these official documents, a huge amount of gateroads sections were drawn on tracing-paper by mining engineers and geometers as working documents. Approximate location of these documents is in most cases possible after a careful check.

Most of these documents exist only in duplicate and variable preservation state. Before encoding, documents must be completely cleaned using a special gum powder and in many cases, consolidated. These documents related to the Belgian coal mining history correspond to a **national heritage**. They must be preserved and are adequately stored in vertical filing cupboards. Due to badly preservation conditions of the plans, a systematic scanning is now performed and will facilitate handling and consultation. The bitmap image of one A0 plan, scanned at a 150 dpi resolution, makes around 24 Mo. Hence, 25 mine plans can be stored on 1 CD-ROM.

Cleaning, labelling and scanning plans as well as other mining documents are time-consuming procedures but are absolutely necessary for document preservation.

## COAL DATABASES

Four main databases have been created using Access 97: coal concessions history, mine plans, mine shafts, coal dumps. These data tables are integrated in the GIS and can be visualised using geographic coordinates calculated for every objects (wells or mine plans).

The GIS (Mapinfo) permits to visualise simultaneously every type of cartographic data. Two types of fundamental objects are integrated in the GIS:

— vector-type objects (points, lines and surfaces like wells, mine plans and coal dumps) with numerical or alphanumerical data associated and;

— image-type objects (raster files like scanned topographic map) without associated data (or attributes).

The GIS contain geographic systems allowing to cross data tables on the basis of their spatial relations. The GIS is the only way to superimpose coal documents on other cartographic documents. Mine plans are "georeferenced" like every other geographic object in the GIS.

Access to these data tables in the GIS start with an overview of the concession map (Fig. 2). Progressive zooming permits to discover more detailed documents such as mine plans (Figs. 3 and 4). Each database can be superimposed on any cartographic support like topographic maps, aerial photos, old maps etc. (Figs. 5 and 6). All of these objects have attributes that allow running queries for extracting the searched document or information.

**Coal concessions history.** The source document corresponds to the last official map of coal concessions, established by the Mine Administration in 1946, at scale 1:40,000. It has been necessary to integrate data on the history of concessions before 1946. A search on one concession history gives a detailed chronological listing of the colliery changes from constitution to closure.

**Mine plans database.** Main attributes for mine plans correspond to identification code and numbers, type and scale of the document, name and code number of the concession, name of the exploited coal seam, depth and dates of exploitation, observations, X–Y geographic coordinates. Coal mine documents are georeferenced as geographic objects into GIS, implying the transfer from local mine coordinates to Belgian Lambert coordinates 72/50. A Mapbasic program permits to automatically transfer the coordinates simultaneously for all the files in the tables.

**Mine shaft database.** Here, the main attributes of each wells of the mine shaft database concern the name, type, depth,

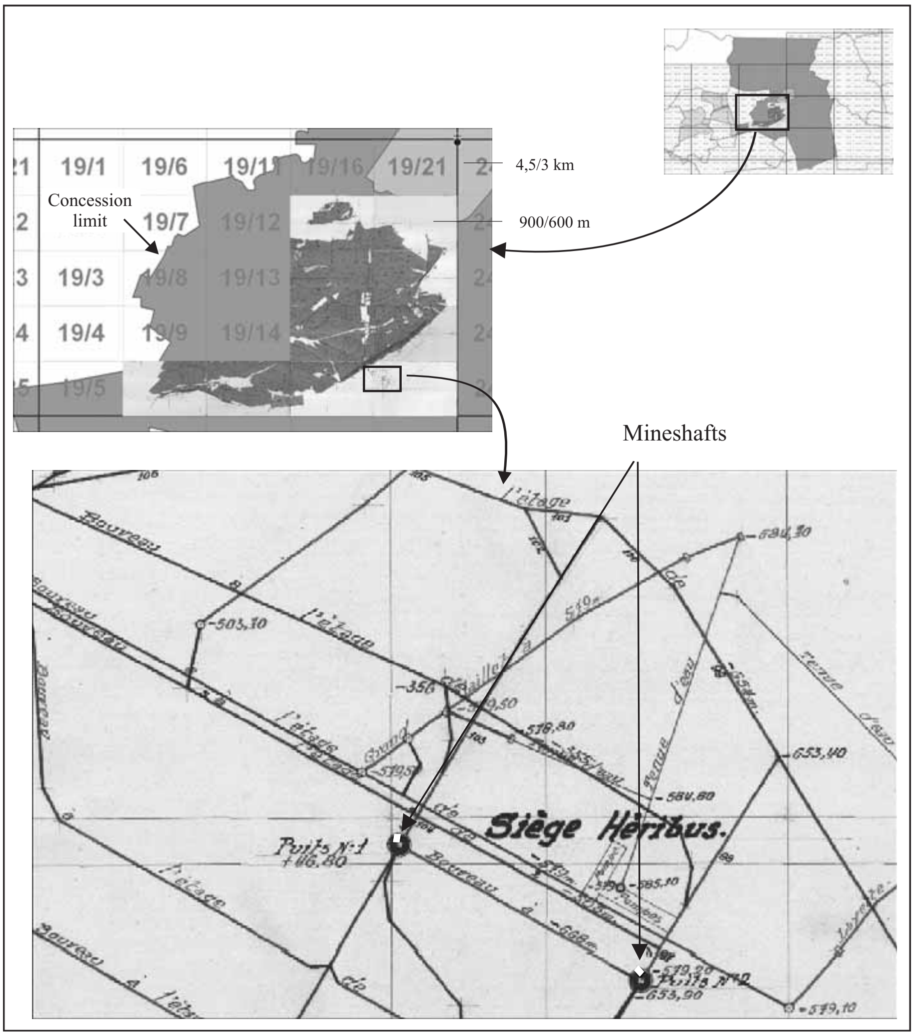


**Fig. 3. Concession map, ten scanned mine plans and mineshafts database are superimposed. The precision of the method indicates a 5 meters error**

name and number of the concession where the well lies as well as geographic coordinates which must also be converted in Lambert 72/50 coordinates.

**Coal dumps database.** The last database created at the GSB concerns the 483 coal dumps inventoried in the southern part of Belgium. All of them are related to extraction wells of collieries. Informations concerning name, localization, geographic coordinates, waste products volume, type and category of coal dump have been systematically described.

Several examples are figured in the following part to illustrate the utility of the GIS. In the first example, ten mine plans from the coal seam named "Veine à l'Aune Superieure" are georeferenced in the GIS (Fig. 3). The plans location is particularly well done in Lambert coordinates as they fit exactly the small mine grid (900 m long/600 m wide). Importing a new layer (mine shafts database), in this case, permits to measure the error between geographic coordinates of wells from database compared to the same wells drawn on mine plans (Fig. 3). The measured error, close to 5 meters, indicates a relatively good precision of the method.

Another example concerns the "Bois du Cazier" colliery (Fig. 4). Starting with a topographical map at scale 1:10,000 close to the Charleroi city, a highlighted zone is revealed on the map and zooming on this zone permits to discover more detailed technical plans. These plans correspond to mining infrastructures close to the surface (mining galleries and wells). The superimposition of these documents, with the same wells from the mineshaft database, allows establishing the precision of the coordinates (Fig. 4). In fact, the error is again relatively weak but this is not always the case. The method limitation depends on the accuracy of the mine coordinates deduced from mine plans. Some collieries have used a local mine grid which is not the official grid established by the Mine Administration. This fact is particularly a reality with the oldest plans.

A special interest concerns the superimposition of different layers in the GIS such as those of the railroads, roads and rivers network in comparison with mine plans (here the "Dure Veine" coal seam, Fig. 5). Underground mining infrastructures have a strong impact on surface human activities, especially when mining infrastructures are located relatively close to the surface. This

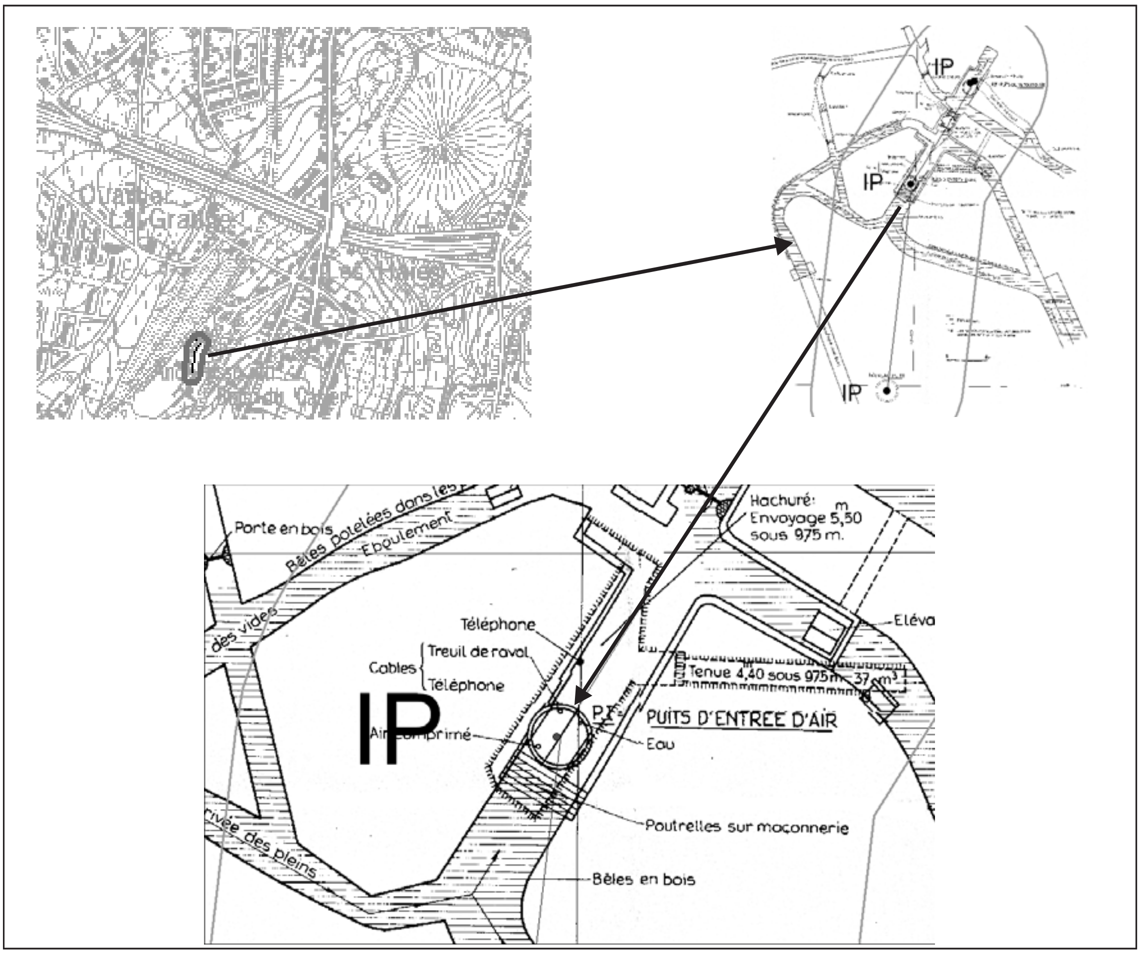


**Fig. 4. Zooming on the selected area drawn on topographic map at scale 1:10,000 gives more detailed mining plans with stonedrifts and wells. A small black point from the mineshaft database are clearly seen in the middle of the wells drawn on the plans**

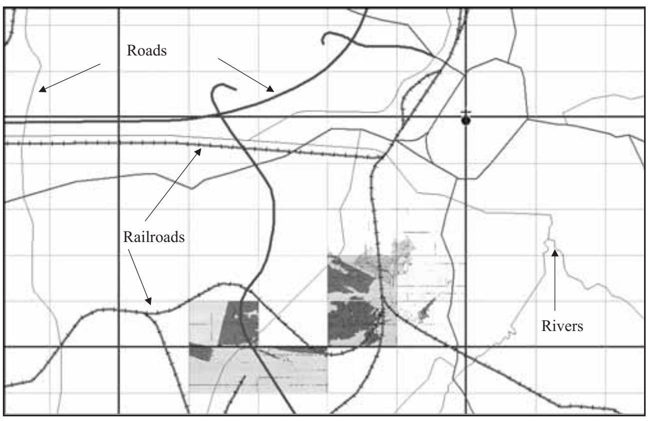


**Fig. 5. Superimposition of different layers in the GIS: mine plans of the coal seam "Dure Veine" as well as roads, rivers and railroads networks**

is particularly true in the southwestern part of the Mons City (Quaregnon area) where numerous mineshafts have been inventoried on mine plans (Fig. 6). In this zone, wells are found everywhere: underneath schools, roads, cemetery, railroads, houses and coal dumps with a density of 1 well for 33-square meters. Exact localization of all the mining infrastructures is therefore urgently needed to prevent new damages.

All kinds of documents —photographs, text, technical drawings, internet pages — can be attached to any geographic objects stored in the database and accessed easily (Fig. 7).

The coal mines database is a particular layer of the urban geological database. Underground quarries, metallic mines, backfillings of old quarries or topographic depressions and reworked soils will be included in the next step, following the same philosophy. Digitalized geological maps, when existing, can serve as basis layer. Each mapped formation is a geographic object with its own attributes. Areas corresponding to a given formation can, therefore, be selected and superimposed to other layers including not only underground voids, but also surface geological data (outcrops), boreholes, geotechnical tests, hydrological information etc. The list is open-ended, making the system powerful.

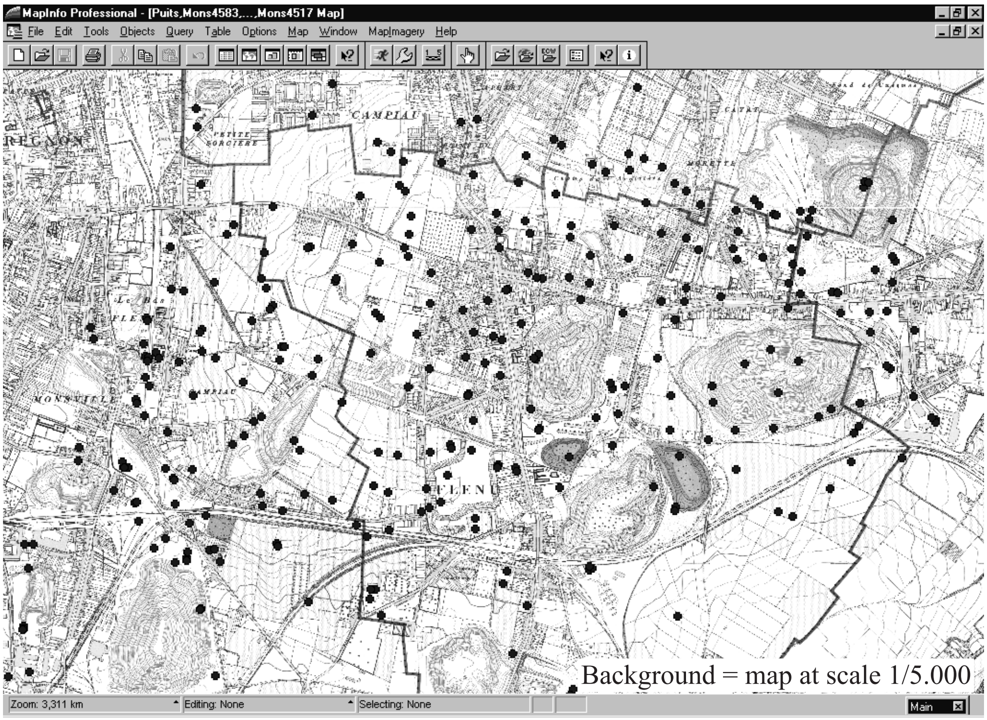


**Fig. 6. Mineshafts, in the Quaregnon area, are present everywhere underneath schools, roads, cemetery etc. with a density of 1 well for a 33-square meters**


**Fig. 7. Wells are superimposed on an aerial photo (Mons area, “Crachet”). The info toolbox and an image are linked with a well**

## STATE OF ART

The creation of a GIS have permitted to develop a computer-aided management of mine documents and information research on collieries of southern coal basin of Belgium. This is the main goal of the system developed at the GSB.

The scanning phase permits to create sixty CD-ROMs, leading to the numerical preservation of approximately 1250 mine plans.

Until now, around 1300 mine plans from 4 concessions are recorded in the database. This part should be almost finished when the 114 concessions, and around 25,000 mine plans covering the coal basin of southern Belgium, will be described. This huge amount of documents implies a long working time to obtain a complete database.

483 coal dumps have been described. The waste products of some of them are used actually during roads constructions. This exploitation implies a change in the landscape and new land surfaces free for human activities. These data must be absolutely indicated and updated in the database.

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