Building of trans-national geologic map databases. The Iberian Pyrite Belt case.
L. Delgado, G. Ortíz, J. Román Hernández and F. Pérez Cerdán
Instituto Geológico y Minero de España. IGME
c/Ríos Rosas, 23. Madrid 28003 Spain

1. Introduction

The Iberian Pyrite Belt (IPB) running across the south of Portugal and the Southwest of Spain is one of the most important areas of Europe for the exploitation of basic metals from massive sulphides. Under the request of the mining companies operating in the area and the regional bodies regulating mining rights and environmental issues, the Geological and Mining Surveys of Spain (IGME) and Portugal (IGM) have built a regional geological and mining information service, integrating and harmonising the geological maps and mining data held by IGME and IGM.

To build up the regional geologic map database of the Iberian Pyrite Belt, the following tasks were worked out:

- to establish standards, guidelines and harmonisation tools to harmonise and integrate the Spanish and Portuguese data bases.
- to establish a common data catalogue and data dictionary to allow the redesign of data bases and GIS components at IGME and IGM with unified structures.
- design of a common metabase and 2-dimensional data models for geologic data.
- to develop a unique access point to metadata and geologic map data over the Internet defining and developing the data management services according with the user interests.
- to develop the electronic delivery services including thematic and 2-dimensional geographical search on metadata, geologic databases and interactive map services over the web.
- development of a theoretical framework giving guidelines to manage and visualise 3D geological and mining information.

The service is based on web servers installed at IGME an IGM in Madrid and Lisbon. Users will be able to access the institutional data bases through those web servers.

2. The IPB Information System concept and need

The need for information services suitable for the management of mineral resources in concrete mineralogenic areas is a must to get sustainable exploitation of the mineral resources, as requested by the administrations, mining companies and the society at large.

To satisfy this request, the Geological and Mining Institutes of Spain, IGME and Portugal, IGM decided in February 1997 to develop an information system to provide geological and mining information to mining companies, operating in the Iberian Pyrite Belt, as well as other interested entities and regional bodies in charge of land planning and environment preservation in the area.
Figure 1. Conceptual diagram of all the information systems interfaced with the IPB Information System and institutional relations involved

Being one of the most important metallogenic areas of Europe for the exploitation of massive sulphides, the mining exploration data held by IGME and IGM are not harmonized, held in disparate data banks, in disparate formats and different coordinate systems, so that difficulting the user access to the data.

So that, data being presently gathered by companies engaged in mining exploration and exploitation activities in the area are not conforming any pre-specified data model or standards. This situation is a barrier for both mining investment and sustainable exploitation of the mineral resources.

On the other hand, there is no on-line geological information service addressed to regional bodies in charge of mining permits delivery and environmental protection. The IPB Information System is intended to fill in this gap, by providing on-line geodata services to both mining companies and regional and local government bodies in the area, on an international framework.

The development has been funded by the European Commission within the Strategic Program Research for Information Technologies, ESPRIT Contract nº 24481.
3. Building of the Iberian Pyrite Belt Data Base

Objectives

The main aim of the project is to build up a demonstrator capable to provide harmonised and structured geological and mining information on a cross border metallogenic area.

The first task to be carried out are the harmonisation and reorganisation of the respective data bases at IGME and IGM, with unified structures, to allow the design of a common Metabase.

The enhancement of the internal Local Area Networks and Internet connection at both sites were also accomplished. In addition, the development of three dimension 3D geological modelling of selected geodata sets and the generation of application programs for 3D representation and retrieval of real geological data through the web were also considered.

To achieve these objectives, the major difficulties were:

- Need to adopt a standard to describe geological and mining data across borders.
- Harmonization effort to get an unique data description of the real geodata: geological maps, mineral occurrences, topography, drill holes, geophysics, …
- Non availability of 3D models and application tools to describe geological objects.

Therefore we had to produce tools for standardisation of cross border geoscientific data, data models and data dictionaries at the geo-data level, a common metabases, and 2D and 3D search tools through the web, as well as the World Wide Web Information Service providing access to 2D and 3D geological and mining data.

Data Bases Harmonization

A common Data Dictionary at the geodata level has been developed for seven selected data bases at IGME and IGM: Geological Mapping, Mineral Occurrences, Gravimetric Data, Aeromagnetic Data, Radiometric Data, Exploration Drill Holes and Prospecting Data

The common Data Dictionary was needed to allow an unique description of the data and of the derived algorithms and attributes. This will allow the harmonisation and integration of all the data with unified semantics and characteristics, allowing the redesign of common structures for each database. To generate the Data Dictionary of the Iberian Pyrite Belt, first the inventory of the available data sets at IGME and IGM was completed, combining and harmonising the data catalogues of both organisms.

Harmonisation of data sets started with the generation of a co-ordinate transformation application, to reference all the geodata to a common projection system, UTM-zone 29. Some guidelines were also produced for homogenisation of cross border data sets, namely topographic maps, geology model, geological maps and legends, geophysics and documents.
Once the data dictionary was produced, the redesign of databases and geographical information components of the Information System was accomplished. A data model at the geodata level was developed for each one of the selected databases.

To prepare the data model a questionnaire on the required searches & services was prepared and circulated to members of the User Groups previously established in Spain and Portugal, integrating the main mining companies operating in the area plus the regional administrations in charge of mining permits delivery. In this questionnaire, specific questions on the possible queries the user might be interested in making while exploring the IPB Information Service were raised.

The inputs from the questionnaire were considered both in the design of the Conceptual Model facilitating the planning of the user queries and in the building-up of the computerised Internal Logical Models, defining the group of tables integrating each database with their respective attributes and access key.

The final data model is based in the Entity-Relation method resulting in the definition of the geological objects (entities) and their attributes, i.e. geological properties or results of specific measurements. The Georelational model developed assumes that geological maps can be described as a collection of structural information, point and line measurements and basic geological units (polygons). The data models represented in CASE tool formats were then developed for each one of the common selected databases.

Figure 2. Conceptual and Internal Models
Meta Data Base

The IPB Metabase was generated following the GEIXS Metadata Model, based in the draft of the European standard TCN/EC 287.

The Metabase is accessed through a catalogue layer including the categories or general subjects. The key subject detail provide access to each of the metabases, which in turn allow access to the data itself. Par of the metabases and all or part of the data are masked to the user, according to their user rights. Multilingual access is possible through the implementation of a multilingual thesaurus in Spanish, Portuguese and English.

Therefore the IPB Metabase allow users to know the information and databases readily accessible into the system.
3-D Modelling

A data set of 3D geodata consisting in exploration drill holes, the digital elevation model of the territory and the geological map of a concrete area within the Iberian Pyrite Belt was selected to develop the 3D geological model for the IPB-IS demonstrator.

The description of the geological objects and of their attributes was made, by using interpolation methods and establishing the relations between the geological entities, allowing the 3D modelisation of the geological objects.

Once the 3D geological model has been validated, it has to be implemented into the 3D demonstrator of the Web Server. This has been done by using state of the art oriented software tools, namely OMEGA tools, developed within the OMEGA ESPRIT Project.

Application programs were generated to transform the IPB geological objects into OMEGA objects with specified file formats, and to accomplish the derived functionalities of 3D representation and retrieval of geodata, i.e.:

- 3D Graphic representation of the 3D data model including view manipulation
- 2D Graphic representation of the 3D data model
- Computation of 2D cross section and level curves
- Volume and Surface analysis
- Information retrieval from graphical queries
- Generation of VRML files to visualize the 3D model through the Web
- Projection of 2D curves on surface
- 3D dynamic cursor co-ordinate
4. Computer and Service Architecture

The physical and logical architecture of the adopted solution, is based in a Client/Server method in which all the components: servers routers, client workstations and software are based in standard open systems.

Software

* Application software based in the client/server architecture providing access to heterogeneous clients to the data base servers.
* To provide document management capabilities in windows through TCP/IP protocols using UNIX servers.
* To solve challenges on large scale data base editing in the World Wide Web.
* Text and attributes retrievals to facilitate searches for specific information.
* Relational data bases client/server systems to manage text and graphics in an open system environment: user verification, access control, concurrency control backup and system recovery.
* Systems able to handle powerful data dictionaries for data definition.

Hardware

Web Servers

* Symmetrical multiprocess capability with high scalability and configuration flexibility.
* Simple, reliable and efficient architecture with high capacity levels and high performance in technical and transactional UNIX applications.
* Integration in high speed networks i. e. ATM, optical fibre.
* File System optimized for management of relational data bases with intensive use of I/O subsystem.
* High Memory ECC (error verification and correction)
* Multichannel I/O for disk replication
* Robust operative system (UNIX family) supporting open system client/server applications.
* CD-ROM
* 1 level caché memory running at the maximum processor speed.

Router

* Supporting LAN Ethernet, Token Ring, FDDI
* WAN connectivity through synchronous lines EI and ATM
* Multilane circuits support, filters, traffic control priorities and data compression
* Ethernet, Token Ring, FDDI, ATM, EI and ISDN Interfaces
* Communication protocols: TCP/IP, OSI, IPX, Decret
The Iberian Pyrite Belt Information Service

The IPB Web Service is available on-line from 1-September-1999

At home page level the user can access directly to each partners homepage and to the GEOMIST service. A brief description of the project and on the Iberian Pyrite Belt is also included. Three languages can be selected: Spanish, Portuguese and English.

To simplify the development and test of new versions, while keeping the service available, there is a development area only accessible by the partners.

The navigation between the IPB services is guided by a first menu with extended options forming new menus with the same properties. The access to some services are restricted to authorised users at three different levels: 1) free, 2) reserved and 3) confidential implemented in specific directories controlled by the Web Server with security protocols, i.e. Hypertext Transfer Protocol with Security (HTTPS).

The service architecture is based in the Client/Server model. A client program (Web browser) makes request to a server program. The server processes the request and return the information to the client.

In the case of interactive services, the request are re-addressed to the specific server e.g. Geographic Information System (GIS) or Database Management System (DBMS). The interactive services implemented into the IPB Web include: Metadata Service, Interactive Map Server and Data Download.

Figure 5. Service Architecture
- **Metadata Service**

The GEIXS Metadata schema was adopted within GEOMIST, while the need to establish a tight connection between the metabase and the database administration lead us to develop an ORACLE based metadata entry application through an interface to the database management system which validates, stores and provides all the data. To insert and update data a Windows interface has been designed while queries to the metadata are made through a specific service in the Web environment.

- **Data Base Query**

The distribution of geographic data through the web is made in three steps:

i) First the access request is formulated and the security system checks the user identification and creates a new session according to the user access level, the server generates then a specific user and request interface access.

ii) The server receives the request message, interprets the contents and get access to the DBMS

iii) Finally the results are packed and returned back to the client in standards form.

To improve the user friendly characteristics, a number of JavaScript programs were developed. Thus there is a function to pack the query components and send them to the server. The query results are sent back to the user, including a list of attributes with hyperlinks that display in detail the selected instance.

- **Interactive Map Server**

This service implements a set of functionalities to display maps according to certain parameters, such as scale, maps legend, map extent, etc.. The map is served as an image which is displayed by the client browser. To manipulate the view (panning, zooming in or out, making visible or not some issues,..) new requests are sent to the server with new parameters that are processed by the server to generate a new map which is returned to the user.

GIS engines are used to implement the interactive mapping services to collect, structure, edit, analyse, export and display GIS data sets as well as for communication with the web server.

The basic architecture of the interactive mapping services is similar to the Client/Server model, where the client is a web browser and the server is a multi-tired server.

The implementation is based in the interaction and integration of distributed processes between the Web server, the GIS server and the Data Base server.
The security of the system is established in two levels, organisation level rejecting other access than to the hypertext protocol through firewall and gateway systems and security granting access to the restricted services through a user name and a password. Part of the metabases and all or part of the data are masked to the user, according to their user rights. The access to some services are restricted to authorised users at three different levels: 1) free, 2) reserved and 3) confidential implemented in specific directories controlled by the Web Server with security protocols, i.e. Hypertext Transfer Protocol with Security (HTTPS).

The maintenance, updating and user access are based on the following criteria:

- Identical data base structure in the Web Servers of IGME and IGM, including an unique Metabase on the whole information.

- Independent administration and updating of the data bases at the geodata level in Spain and Portugal, but common administration and updating of the Metabase. With this approach the risks inherents to a common information management, i.e. data property, information integrity at the geodata level, query control to each institution, etc... are minimized.

- Unique user access through Internet to the Geomist Web Server on the Iberian Pyrite Belt. It will be transparent to the users if the requested information is located in Spain or Portugal. Unified queries sintaxis will allow to the users to get with an unique query the information requested that is available in both Servers.

- Common Metabase management, through common updating system (mirroring)

- Queries to the Metabase will be free while queries at the geodata level will be restricted to different users categories depending on the agreements between IGME, IGM, Junta de Andalucía and Mining companies.

5. Summary and Conclusions

The applicability of IT to the management of mineral resources in a transborder metallogenic area, has been demonstrated.

Active implication and feedback of both administrative bodies regulating the environmental aspects and mining permits delivery as well as private mining companies operating in the area has been very high and useful, proving the acceptability of this type of information system.

The advantages of the system giving a one stop shop for the geological and mining information in the area, are recognised by the mining companies, reducing the information search costs before investment decisions area taken, and by the administrative bodies that can have access to well structured and comprehensive information needed in the decision making processes.