PRELIMINARY STUDIES OF CASTAÑO RIVER BASIN ENVIRONMENTAL BASE LINE, SAN JUAN, ARGENTINA

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ABSTRACT

Río Castaño basin is located in one of the most potential geological-mining areas of San Juan Province to the western sector of the Argentina Republic.
Decades ago important extractive mining labours were developed and taken as a base to begin new exploratory tasks not only to increase the existing reserves but also to situate new deposits.
The activities achieved within the area under study have modified the environment in a neither qualified nor quantified condition, in such a way that it is necessary to diagnose its present state before starting more contaminating activities which may cause severe environmental alterations.
This paper is included within the research project "Study of mining activity effect on Castaño River basin environmental components – San Juan Province – Argentina" and gives details as regards the methodology applied to carry out base line studies of the above mentioned area.
Results obtained from previous preliminary water, soil, vegetation, fauna, geology, geomorphology, seismicity and environmental legal system studies will be used to determine vulnerable environmental components to such an activity.

GENERALITIES

Castaño River basin is developed towards a NW-SE trend between 30º 45' and 31º 20' South Latitude parallels, in Calingasta Department. It is surrounded by Frontal Range and Western Precordillera mountains of about 6,000 m and 3,800 – 4,000 m high, respectively.

Castaño River is the main collector within a wide hydrographic net which comprises principal influing rivers such as San Francisco and Atutia Rivers and some other minor tributaries such as Manrique Creek, de la Puerta and San Francisquito, de Las Burras and others (Figure 1).

This drainage net covers an area of 7,330 km^2, approximately and has a dendritic to subdendritic pattern where a noticeable structural control of river course can be easily seen.

According to Koëpen's climates classification, this zone corresponds to the so-called E.T. i.e. Tundra similar to polar regions and to BS and BW, meaning that there exists dry climate areas full of steppes (rockroses) and desserts, respectively. Mean temperatures are of about 15º C with 30º C summer times and 5º C to –10º C in winter. Pluvial rains increase at higher levels from 80 to 145 mm annually exceeding the 2,000 high above sea level and decreasing progressively to minus 50 mm.

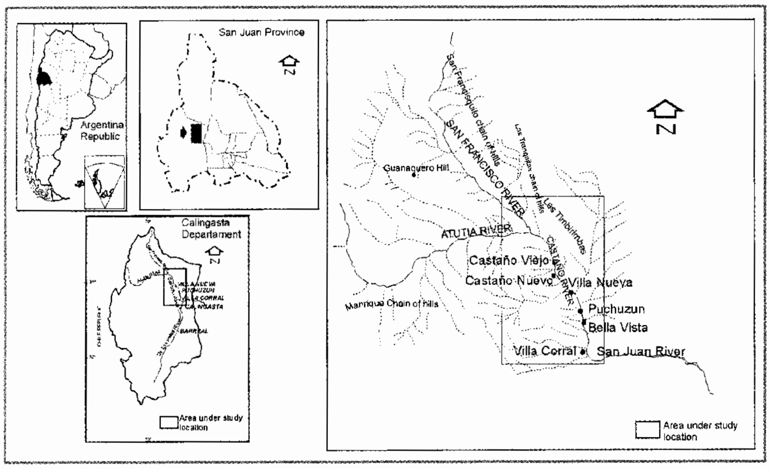

Figure 1. Location of the area under study.

BASE LINE STUDIES

Geomorphology and Geology

To fulfil these research works the below mentioned staged were followed: background compilation, regional and local analysis through satellite images, geomorphology features analysis and field work. Results were used to analyze a preliminar characterization of the area under study.

Relief includes three different morphological units closely related due to genetic features and the climate influence, such as: Cordillera, Precordillera and Intermountain Depression.

The Cordillera, the youngest structure, is situated to the west and its architecture is characterized by units which are alternatively high and deep-set. They conform complex neotectonic landscape associations conditioning the permanent and temporary river courses trends.

The eastern Precordillera is a unit with a minor topographic hierarchy and forms a group of parallel chain of hills of about 3,000-3,500 m above sea level.

The Intermountain Depression among them, corresponds to a sunken socle block forming a wide longitudinal valley with detritic accumulations which allow the main collectors flow within a large drainage system: Los Patos and Castaño rivers. Such hydrographic net is structured by the basal reliefs supporting it and it is also characterized by its tectonic and lithologic conditions.

Castaño River basin is characterized by its terrain development located between Western Precordillera and Frontal Cordillera. Those belonging to the former range conform a Paleozoic sedimentary sequence affected by Miocene intrusion and effusions. Paleozoic sequence intruded during several orogenic processes ranging from the Upper Paleozoic to the Cenozoic.

The whole basin is affected by NW-SW and N-S and E-W faults. Such faulting has favoured the metaliferous deposits settling, mainly in the cordillera sector .

Magmatic activity has mineralized significant areas with disseminated and veined deposits.

Water resources

This task was performed in two stages. The first one involved the compilation of historical and hydrological data of Castaño River basin in Argentina Republic and San Juan Province governmental bureaus.

Due to this fact it was possible to collect information as regards river flows and underground and superficial waters physical-chemical composition.

The second stage was devoted to superficial water sampling in accordance with a preorganized plan. The first objective was to take samples from next historical sites so as to correlate all the information available. So, it was possible to determine a sampling net in Castaño River sites and in two of its main tributaries, San Francisco and Atutia River.

Some in situ determinations were carried out during fiel labours employing the required instrumental.

- *Specific electric conductivity at 25º C*
  This parameter allows to evaluate water salinity or mineralization. For this kind of determination a WTW LF 330/SET portable equipment was used.
- *Dissolved oxygen*
  It indicates the organic matter presence in waters. A WTW OXI 330/SET portable equipment was used.
- *Potentiometric pH and temperature*
  The first influences the corrosive or incrustating action of waters. A portable HANNA equipment was used for both of them.
- *Oxygen Biochemical Demand (DBO)*
  It shows chemical contamination and the quantity of oxygen required by micro-organisms while degrading organic matter. It can also indicate the organic contamination charge. A WTW Oxitop-IS6 portable equipment was required.

For a complete laboratory sample test, three predetermined point samples were used:

- Main drum: 2 liters capacity. The recipient was rinsed three times with source water. Then, it was completely filled to avoid air chambers and the lid was put on. Finally it was sent to the laboratory for a complete physical-chemical test.
- Secondary preserved drum: 0.5 liters capacity. The sample was taken following the above described procedure, but with the addition of 1 ml of 50% nitric acid. Samples were sent to the laboratory for iron, aluminium and manganese tests.
- DBO secondary drum: 0.5 liters capacity. The same procedure was performed, but without any addition. Reci-

pients were put in a cold storage to keep the sample in minus 4 ºC.

Once identified, samples were sent to the central laboratory at the Institute of Mining Researches (IIM) for testing.

The following determinations have been performed:

- *Main drum:*
  - * Main ions: calcium, magnesium, sodium, potasium, carbonates, bicarbonates, sulphate and chloride.
  - * Minor elements: chromium, cadmium, copper and lead.
  - * Chemical and physical-chemical determinations: temperature, pH, potentiometric and specific electric conductivity at 25 ºC.
  - * Chemical properties: total alkalinity, total hardness and non-carbonates hardness.
- *Secondary drum with nitric acid addition:*
  - * Minor elements: iron, aluminium and manganese.
- *Frost secondary drum:*
  - * Pollution chemical indicators: (DBO_5^{20})

An aliquote of the principal sample was sent to the National Institute of Water – San Juan Bureau (INA- San Juan) for boron and arsenic tests.

From determinations achieved during the preliminary stage, it may be concluded that waters being studied have a very low salinity which is high mountains common feature. Toxic substances not presence, such as heavy metals, at contamination levels. Dissolved oxygen and DBO values would indicate the absence of organic matter.

Soils

According to the most common classifications three different physiographic areas can be easily distincted in the zone under study (National Institute of Farming Technology, INTA, 1987) (Figure 2):

- Mountanious chain of hills being of diverse age and lithology rocks. Sediments of a very thick size within scarcely developed soils have been deposited in concavities and surfaces with slight slopes.
- Coalescent alluvial cones where thick non-selected creep materials prevail being conformed by blocks and gravel within a thick and medium size matrix.
- Central valley beaches where eolic-fluvial deposits predominate being of thick and medium granulometry supported by fines material such as: sands, lams and clays. The alluvial filling may be considered as a modern one, bearing in mind the idea that there is a large material emplacement from higher parts towards the valley bottom and that those sediments fail to be completely evacuated to the extra-hilly plains. Based on geophysical data it may be estimated that phreatic level would be at about 6-8 m deep.

In order to corroborate the available information and based on a geological criterium a geochemical sampling (rock, soil and flow sediments) was carried on. Samples are being chemically and mineralogicaly analyzed for an accurate characterization to determine vulnerable zones derived from natural or induced actions.

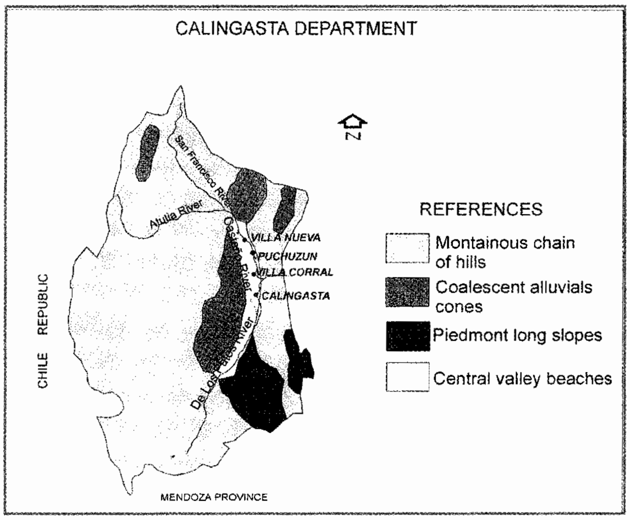

Figure 2. Types of soils within the are under study.

Seismicity

Seismicity analysis of the area being studied was elaborated based on researches achieved by national governmental institutions devoted to that field of knowledge such as the National Institute of Seismic Prevention (INPRES) and the Institute of Antiseismic Researches (IDIA) at the National University of San Juan.

San Juan province is characterized by its high seismicity hazard. Although it may be observed that some areas have more earthquakes concentrations than others, it is impossible to find a place not involved in this kind of seismic activity within the whole province.

Different structural and morphologic features can be seen in San Juan Province. The most relevant for seismic hazard analysis are the ones known as "active failures". Some authors have even located various potential seismic sources and remarked that some of them would generate destructive earthquakes.

Historically, never been Calingasta Department there has any destructive earthquake epicentre. Nevertheless, earthquakes of diverse magnitud and intensity have been detected (IDIA, 1998). It may also be noticed that there is seismism in some other sites of Argentina and Chile.

One of the most seismic hazard potential regions, El Tigre faulting system crossing Calingasta Department from North to South (Figure 3) is located next to Castaño River populated settlements. This system is related to a destructive earthquake occurred in 1894 its epicentre being at about 120 km North. The previous data show that Castaño River area has a high probability of undergoing a severe earthquake which may cause serious human and material damages.

The isoseismals curve derived from such an earthquake with an intensity of VII of the Modified Mercally Scale (MM) (Figure 3) goes across the area under study registering the high seismic probability. The INPRES analysis coincides with the previous information and confirms that the basin area is within a zone with a high probability of suffering maximum intensity earthquakes of about VII and VIII of the MM.

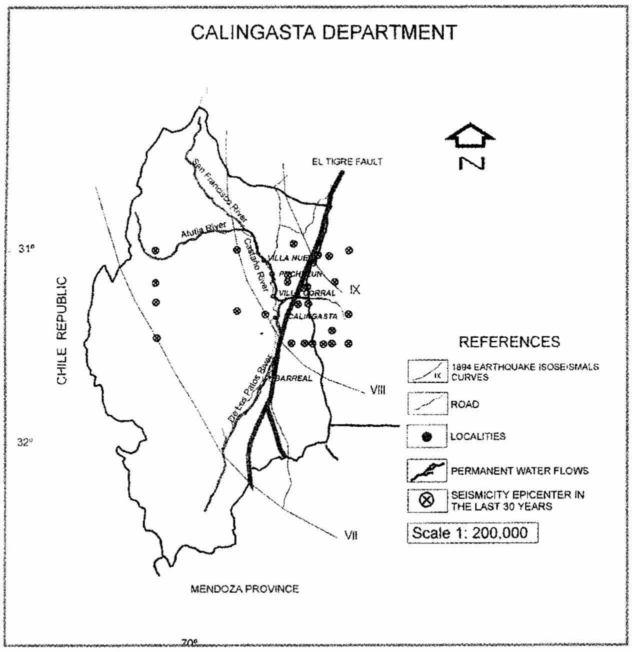

Figure 3. Seismicity elements within the area under study.

Another feature to be considered when analyzing seismic hazards is the kind of soil. Having INTA studies which have determined the existance of three different types of soil i.e. mountanious chain of hills, coalescent alluvial cones and central valley beaches. Due to the beaches characteristics they may be the ones responsible for the liquefaction phenomenon which increased earthquake consequences.

If hazard is defined as "a group of physical features distinguished by a potential dangerous, hazardous or risky phenomenon" (Ayala, 1990) and the above analyzed features are taken into consideration together with the fact that populated settlements are located in Castaño River valley with the deriving basin economic activity; it may be concluded that such valley has the highest percent of hazard from the seismic point of view.

Vegetation

Thirty six phytosiciologic surveys were carried out in the area under study during the first stages of this research work.

Most of them, twenty-one, correspond to predictable high impact mining activity such as those communities located within Castaño River flooding plain. Two different kinds of communities can be observed: a) The river flooding plain dynamic communities which are determined by the follow annual pulsation, b) Those communities which are related to minimum flows demanding more humidity. Ten surveys were carried out at Castaño River spring nearby areas; the remaining ones were situated downwaters, in sites next to Villa Nueva and Villa Corral (Figure 1).

Fifteen surveys are related to those sectors within the studied area, but they fail to be directly influenced by the river. Surveys were arranged according to an altitudinal gradient and a preferential stratified sampling at every 300 m. Results obtained will be applied to characterized the zone from the regional point of view.

The following vegetation communities were also characterized:

Altitude shrubby steppes

- *Larrea divaricata community*
  This community appears in Precordillerean valleys and plains in sandy-stony soils and in the eastern Andean hillside to an altitude of about 2,700 above sea level.
  Its physionomy can be described as a low wide bushwood of *Larrea divaricata* of about 0.80 m high. Among the most important species conforming such a community, it is worthy to mention the *Larrea cuneifolia, Senna rigida. Prosopidastrum globosum, Fabiana denudata, Lycium tenuispinosum, Bulnesia retama, Gochnatia glutinosa. The grassy stratum is poor and sparse, but Stipa sp. Pappophorum sp, Munroa sp.* and so on, can easily be seen.
- *Ephedra breana and Lycium chañar community*
  Physionomically it is represented by a bushy steppe of about 0.50 m high, located over 2,700 – 3,000 m.a.s.l. The different slope conditions, expositions, soils and height interactions make the vegetation of this area to be of a great variety composition i.e. *Boungainvillea spinosa, Junellia sp., Maihueniopsis glomerata, Baccharis incarum, Gymnophyton polycephalum, Dolichlasium lagascae.*

Vegetation of flooding flows and plains

It refers to river flow vegetation.

- *Bredemeyera colletioides bushwoods*
  Physionomically it is a wide bushwood 1.50-2 m high. It is located in the basin rivers flooding plain. It is even more developed in the wide Precordillera valleys flooding plains. Its dominating species is *Bredemeyera colletioides* and some other surrounding species are *Baccharis retamoides, Cortaderia sp., Hyalis argentina, Cercidium praecox, Senecio subulatus, Eupatorium buniifolium, Mentzelia albecens., Acantholippia sp.*, etc.
- *Escallonia angustifolia bushwood*
  Pure and dense *Escallonia angustifolia* bushwood 2.50 m high can be found in the higher, faster and narrower river basin banks. This kind of bushwoods are located in the river flow humid borders creating a large radical system which allow them to be adapted to the river periodicals mountain streams.
- *Tessaria absinthioides bushwood*
  This community is present in less slope sectors and more inflowing rivers in the flooding plain. It grows either in banking or fine sediments deposits zones. These areas may become isles among various river flowings. Such a bushwood may be 1.20 m high of almost pure

compact *Tessaria absinthioides*. Some other species to be mentioned are: *Tessaria dodonaefolia, Baccharis salicifolia, Eupatorium buniifolium,* etc.

Vegetation of minimum flows

- It refers to grassy vegetation closely related to high levels of humidity and water flow. This kind of vegetation may be partial or totally destroyed by periodical flow floods. Among some other species the following may be mentioned: *Juncus microcephallus, Ranunculus cymbalaria, Veronica anagalis, Centaurium pulchellum, Oenothera longituba, Poligonum montpelliens, Hordeum halophyllum, Mimulus luteus, Mimulus laceratus, Plantago lanceolata, Apium sp.* etc.

Fauna

The fauna inventory, its habitat evaluation and the conservation status of every registered species was carried on these following stages:

First stage

It included the study of these fauna groups: Stockfauna, Birdfauna, Ichthyofauna, Herpetofauna using a stratified sampling technique (Tellería, 1986).

Stockfauna deals with major mammalians (camels), medium sized mammalians (chamois, felines, gnawings, lakedforms, toothedforms, marsupials, etc.) and small-sized mammalians (gnawings, micromarsupials). Surveys (examplaries watching, excrement, prints, skeletons, etc.) as well as traps for small mammalians, such as the Shermann and spring-like ones, are used.

Birdfauna works were carried on with the whole group, through detailed observation of examplaries, nests, excrement, egestions, prints, pebbles and so on employing fog net traps and photographic capture.

When dealing with herpetofauna the whole group is also involved through surveys and detailed observation, capturing animals alive using ropes or dead animals with forks, and Barber falling traps so as to collect reference animals for a correct systematic determination of doubtful cases.

Ichthyofauna uses pulling nets and funnel traps (Chani, 1980).

The collected exemplaries are sent to the Natural Science Museum and Institute at the National University of San Juan.

Sequence and family arrangement as regards scientific nomenclature are based on the following models: Arratia et al. (1978), Arratia and Menu-Marque (1981), Cei (1980), Cei (1986), Cei (1993), Etheridge (1995), Fjeldsa and Krabbe (1990), Narosky and Yzurieta (1987), Nores (1991), Olrog (1979), Redford and Eisemberg (1992), Ringuelet et al. 1967, Wilson and Reeder (1993) and Williams and Francini (1992).

Second stage

It was based on Grigera and Ubeda's (1990) methodology which was adapted for this purpose.

According to the habitat, particular features are defined. Strata are differentiated in each habitat and each species is assigned with a given feeding or reproduction stratum. The most useful strata are determined and a bidimensional matrix is elaborated. Finally, the most important combination is selected.

These data is the base to establish the most dominant biologic type taking into account feeding and reproduction features, feasible and required strata i.e. prior species considering the preservation point of view in every environment. For example, species which may be affected by mining activities and so on.

For the preservation evaluation state of the species under study Reca et al. (1994) method is applied. Species are here classified within an index (SUMIN) formed by 12 variables values which are relevant for their survival and preservation: Continental distribution (DICON), National distribution (DINAC), Amplitude for habitat usage (AUHA), Amplitude of vertical space usage (AUEVE), Body size (TAM), Reproduction potential (POTRE), Trophic amplitude (AMTRO), Abundance (ABUND), Taxonomic singularity (SINTA), Singularity (SING), Extractive actions (ACEXT), Degree of protection of species (PROT).

Each variable (vi) has a given value within a determined range for each species to be considered. The highest value corresponds to the most adverse situation for the species being studied.

The qualification index resulting from these values addition may range from 0 to 30.

$$\text{SUMIN} = \sum\nolimits_{i=1}^{12} vi$$

Species are organized according to the SUMIN value so as to get an arranged listing including their preservation state and urgency.

Forty four species of vertebrates were distincted: 1 Fish, 1 Amphibians, 4 Reptiles (3 Saurian and 1 Ophidians), 37 Birds and 4 Mammalians. Among them the following orders can be pointed out: Silurianformes, Squamata, Rheiformes, Ciconoformes, Accipitriformes, Falconiformes, Charadriformes, Columbiformes, Psitaciformes, Apodiformes, Coraciiformes, Passeriformes, Carnivora and Artiodactyla.

This is a preliminar result derived from the first stage.

Environmental legal system

A detailed review of the prevailing environmental legislation in both Argentina Republic and San Juan Province was carried on to identify the norms to be applied in a given mining project.

Law # 24,585 about "Environmental Protection for Mining Works" and its reglamentation about such activities as regards environmental preservation were promulgated in 1995 modifying Article #282 included in the Nation Mining Code. This article is also incorporated as a complementary headline in an arranged text being of the whole nation competence.

This is a significant law since it specifies mining activities and fortituous impacts upon these circumstances as regards environmental effect. It involves not only a preventive but also a non-reactive character being favoured by the incipient status of Argentina mining activities.

This law establishes limits for its pursuit and application, environmental management instruments, protection norms, environmental conservation responsibilities for environmental damage, infringement, sanctions and it enhances environmental education and defence, as well.

CONCLUSIONS

Every article involved in the environmental base line has been evolved following a methodology which has successfully been applied. Environmental items have been characterized in this way and they will be used in order to carry out an environmental diagnose of Castaño River basin.

Furthermore, critical areas and feasible environmental components related to mining activities in that region will also be defined.

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