Coal Deposits of Colombia
Andrea Jähnig
Supervisor: Prof. Dr. N. Volkmann

Abstract
Colombia owns the biggest coal reserves of Latin America. Therefore Colombia belongs only to the younger exporters at the world market. The coal reserves amount to about 9.8 billion tons and 6.6 billion tons count as sure proved and minable. The quality of the coal is good, most reserves exist of high-quality bituminous coal and only of tiny amounts to metallurgic coal. The coal is relatively clean and has a sulphur content about 0.7 % in average. These are geological young coal formations from Upper Cretaceous and the tertiary Age. Nevertheless, the weakest limb of the coal chain is still the infrastructure. In spite of many improvements during the last years it is yet not possible for the most export companies to use their conveyor capacity completely. Also the other development of the mining runs in spite of favourable bed terms and coastal nearness of a large part of the coal beds only hesitantly.

Introduction
Coal is the most frequent fossil fuel of the earth and reserves of it were proved in more than 100 countries. With the speed of the present production coal on our planet is available more than 200 years and so it is much longer available than oil and natural gas. Many countries of the world have large coal reserves, nevertheless these deposits are currently economical non-recoverable, like other raw materials. This will possibly change in the next few years.

Geological structure of South America
The geological structure of South America is determined by three big geologic regions, which are also tectonic and economic areas: The old shields, the young high mountain massives and the young sedimentary basins (REISS & STÜBEL, 1899). The young mountains of the Andes are rising along the whole pacific coast. Uplifted in the Tertiary, it is marked certainly by the tectonic active continental edge, and by intensive volcanism and heavy earthquakes. In contrast to the Andes the low mountain ranges of South America are tectonic quiet. Originated in older mountain formations, today they are no longer foldable and generally tectonic quietly. These are the old shields and the rests of the precambrian basement, but also of the Variscan mountain formation. There you have either the upcoming depth rock at the surface, or it is overlaid from mostly thin Mesozoic and Cenozoic sediment series (REISS & STÜBEL, 1899). In the end, there are young sedimentary basins, which are named by their main receiving water course. These are for example the Orinoco Basin, the Amazonas Basin and the La Plata system with the decisive rivers of Paraguay and Paraná and less important inland basins, which can also be discharged in the dry climate of northern Argentina or form large marsh landscapes, as for example the Pantanal.

The Andes: A short overview
The Andes, (Central America the Cordilleras), crossing Latin America in its whole
from north to south and are therefore with 7.500-9.000km length the longest mountain chain of the world. In contrast to the precambric basement of South America the Andes belongs to the most agitated and most mobile crust parts of the earth. The reason of the formation of the Andes to a high mountain lies in the dynamism of the great plate system of the earth. The oceanic east-pacific plate subducts constantly below the South American plate. Parts of the old shields of South America were incorporated in the formation of the Andes. The melting of the pacific plates in the subduction zone causes that volcanoes form the landscape of the Andes. In the front of the coast-line is a deep-sea trench with about 6000m depth situated. The trench ranges from Chile to Mexico and so provides a steeply continental slope on the western coast of Latin America. When appearing as a unit in extensive morphological relief-structural maps, there arises a more differentiated picture of the Andes after more precise consideration. The mountains are built up by single north-south gliding ranges. In the central part the Andes moving to the west, because of a offshoot of the Brazilian shield. The single mountain ranges are separated of each other by tectonic dropped crust blocks and are filled in with younger sediments. The Andes can be divided in three big areas:
The North Andes spread out from the Cordillera de Mérida in Venezuela up to the mountain knot of Pasto on the border of Colombia and Ecuador.
The Central Andes apply from Nudo de Pasto possibly up to the Llullaillaco in North Chile.
The South Andes reach from the Atacama Desert up to Cape Horn.

Colombia - The North Andes

The morphological structure of the Andes of Colombia shows the structure of the North Andes with its three cordilleras. The West Cordillera, Cordillera Occidental, is separated by the valley of the Río Cauca of the Central Cordillera. Between this and the East Cordillera, Cordillera Oriental, lies the wide valley of the Río Magdalena. Architecture and structure of the three mountain ranges are absolutely different (许泽, 1925-1927). The distinctive subsistence areas, zones with big sinking trends, between the Cordilleras chains of Colombia and Venezuela are noteworthy. Between the Pacific and Cordillera Occidental lies a hilly coastal area constructed from mighty tertiary sediments. In the North Andes there are a lot of tertiary coal deposits with huge reserves. The only higher elevation is the Sierra de Baudó (1810 m), a Mesozoic volcanic complex. Eastwards slightly mead-amorphous clay schist and chert schist which are covered by mighty basaltic vulcanite caps. This complex builds up the West Cordillera. Today one interprets this structure as a rest of an oceanic plate with island arc volcanism which was attached to the continental crust of South America in the Tertiary. The Central Cordillera is determined by old Precambrian and old Paleozoic rocks. Typically for the Cordillera Central are metamorphic rocks, like phyllite, quarzite and metamorphic conglomerates. They show a distinctive schistosity and sharp folds. The metamorphites are diskordant overlaid by Devonian and Lower Carboniferous continental sediments as well as Upper Carboniferous and Permian marine sediments. In the east edge is a mixture of Triassic ignimbrites and Cretaceous conglomerates, graywacke, pyroclastics and lime-sandstones. Indeed, the East- and West-Cordillera reach likewise substantial heights, however, the Central Cordillera were lifted till Cretaceous immensely. It is also the only area of Colombia that was formed by volcanism, which started in the Miocene. The highest summits are built up by very young volcanoes. The east cordillera has a complex structure. At first is in three areas the pretriasic basement upcoming to the surface. From the south to the north these are at Garzón, at the area Quetamé and at Santander. In itself this body is likewise built up very heterogeneous. The rock contains high metamorphic gneisses and granulites. A wide area is taken by immense marine Cretaceous series which are laying diskordant above the old basement. In contrast to
tectonic strongly subdivided basement only very weak folded structures are to be observed in the Cretaceous - unusually, in addition, this mighty layer package was not grasped by another orogenesis. Younger tectonic activities also play a big role in the northern basement clods of Colombia. The Sierra Nevada de Santa Marta and the substantially lower peninsula Guajira are separated of the rest of the Andes by lowering zones. The Sierra Nevada de Santa Marta is a block separated by tectonic structures in all directions. The highest point of the mountains is imposing: Cristóbal Colon with a elevation of 5776 m over sea level lies close to the Caribbean Sea. As in the other northern mountains of Colombia the Sierra Nevada is also characterized by complicated structures inside. Facing to the block-like high mountain basement lies far dropped crust parts, filled up with mighty sedimentary layers. One of the most important fault zones of the Andes is the W-E running system of the Oca-fault, which can be followed up in the east to the Venezuelan Sierra Mérida. Even in the old tertiary were vertical movements of several thousand metres there effective, the strongest vertical trends of the Andes. Still in the Eocene led movements to a horizontal displacement of 15-20 km. These and other faults of the Sierra Nevada are interpreted as expression for activities between the Caribbean-South American tectonic plates.

**In general: Coal deposits of Colombia**

Only a short time ago foreign investors have perceived the whole potential and the extensive coal beds of Colombia. They are in seven coal basins, whereof the districts Guajira and Cesar near of the coast are economically to the most interesting areas. The largest reserves are situated on the peninsula of Guajira. Reasons for the beginning of coal mining activities in Colombia gave the offer shortage released by the second oil crisis in 1979/1980, and the situation at the steam coal world market dury this period. At this time decided the American mineral oil group EXXON together with the colombian state enterprise CARBOCOL starts the common development of the deposit El Cerrejón North on the peninsula of Guajira. The mineral resources are a communal property and in federal possession. The Colombia government decides on their use. The supervision about the coal mining exercises to the ministry of mining and energy subordinated authority ECOCARBON. She examines the coal resources of the land on her capacity for economic development, provides for this the first concepts and writes advertises the deposits by private enterprises in international afford processes. Most of the mining concessions have validity for 30 years. For all promoted coal the state a conveyor interest of 5% of her sales proceed raises. More than 90% of the coal contracts are long-term contracts. During the last years Colombia has developed to an important global exporter. The country exported already in 2007 about 70 Mil. Metric tons of coal (see Fig.1).


Fig.1: Colombia’s Coal Production in metric tones; [http://www.galwayresources.com/s/ColombianCoal.asp](http://www.galwayresources.com/s/ColombianCoal.asp)
At the moment, Colombia is the biggest export country for the USA, the second biggest distributor for Europe, and the fifth biggest exporter worldwide. This will be change with the expansion of the Panama Canal. After than, Colombia has the chance to conquer the Asian coal market. The richest coal deposits are distributed well over the northern and western regions of Colombia, however the biggest export operations limit themselves to the provinces of Guajira and Cesar in the North of the country.

Indeed, widespread small and middle size coal deposits also exist in the regions of Norte Santander, Santander in the Northeast, and Cundinamarca in the centre of Colombia.
However, these matters less because they diminish together less than five million tons of coal per year and the mining method are relatively primitive. Most of the metallurgical coal is located in the area of Boyocá, Cundinamarca, and Norte Santander but the biggest part of the production is used for the local industrial application. The coal reaching in the export was produced nearly without exception in opencast technology. The bed formations are stored as a plane level, reach a size from up to 150 m and thickness from 1-15 m. A current mining method is the Heavy truck/excavator-operation, now and then supported by dragline excavator to the distance of the slope final overburden. In the civil engineering works, as far as known, only one export pit, this is only partial-mechanised and pursues chamber/pillar construction by means of drilling and shooting. Substantially the civil engineering is not spread under statistically grasped and for the local need supporting small coal-mines. Presently, two railway lines are available for the coal transport to the coast: From El-Cerrejón North to the harbour of Puerto Bolivar (145 km) and from Mina Pribbenow/La Loma to Cienega/Santa Marta (210 km). Both harbours are located at the coast of the Caribbean Sea, indeed, the use of these connections is left only to both great producers, so that smaller exporters still remain on the costly transport with trucks to the coast. Meanwhile, Colombia owns six export harbours which are able to load coal freighter of Capsize. With Offshore moorings like Puerto Drummond and Puerto Prodeco in the bay of Cienega, the freighters will load by barges and by floating cranes.

![Fig.3: General Map of North Colombia and the position of the export harbours;](http://www.galwayresources.com/s/ColombianCoal.asp#)
6 Andrea Jähnig

La Guajira
El Cerrejón

El Cerrejón is the biggest open coal opencast mine of the world and is situated on the peninsula Guajira, Northeast part of the country. The region of Guajira disposes of well developed road system and of a 145km long good railway line which transports exclusively the coal of the mine.

The deposit is divided into four zones:

Zona Norte: El Cerrejón Norte originated as a joint-venture between the Colombian state (Carbons de Colombia SA, Carbocol) and Intercor. The cooperation began in 1977 as a research project, became in 1980 the construction project and went already in 1986 to production.

Zona Central: Zone Central is since 1981 in production and was acquired according to the contracts following on each other with different companies in 1995 by Glencore. At this time Carbones Del Cerrejón S.A was founded. Already in 1997 joined AngloAmerican and in 2000 BHP Billiton became the third partner.

Zona Sur: The Colombian state offers the exploration and mining in Zone South, so a syndicate was created in 1997 which later got assigned to parts of BHP Billiton, AngloAmerican and Xstrata. This zone still is in exploration.

Zona Oreganal: The Zone was decided at the beginning between Carbones Del Caribe and the Colombia state.

El Cerrejón owns a size of about 69,000 hectares and is an efficient and reliable supplier for coal at the international steam coal market. It’s a bituminous coal from tertiary age with a ash content of 7.5% in average. The moisture amounts to 11% and the sulphur content below 0.7%. Therefore this coal is suited very well for the energy production and for metallurgy. The reserves of the deposit are the biggest of Colombia and amount to approximately 950 Million tons of coal to 100m depth, 2,000 Million tons to 200m depth and 3,000 Million tons up to a depth of 300m. The coal is extracted in seven open pit mines. The customary bank thickness amounts to 15 m. After cleaning up the top soil, the overlying rock got drilled and blown up, then the rock material is transported on a dump, this happens through twelve P&H 2800 electric mining shovels which are equipped with 27.5 m³ shovels. The coal lying open now is used by means of bulldozers and is carried if necessary with the help of detonations from the harder rock. Under use of L-1100 and L-1200 excavators with 25 m³ shovels the outworn coal is loaded into 16 skips with a capacity of 154 t. These transport the coarse coal to a crushing unit where the coal is chopped up in a two-stage process on a size of 50 mms. The crushing unit owns a capacity of 3,500 t/h and the chopped up coal is carried in two loading silos until it got transported to the harbour. Because El Cerrejón is connected with the harbour of Puerto Bolivar by a freight railway line, the diminished coal can be transported immediately by two trains. Both trains consists of 120 wagons and are able to transport 48,000 tons of coal during four journeys per day to the harbour. The coal is loaded either immediately on the ship, else is transported in warehouses up to the export. In the harbour of Puerto Bolivar become the ships, up to a capacity of 175,000 tons their cargo through one single loading bridge with a capacity of 10,000 t/h. The conveyor amount in 2003 is about 22.58 Million tons, in 2006 about 28 Million tons and for 2008 are aimed an extraction of 32 Million tons. El Cerrejón engage 7800 workers.

La Cesar
La Loma/Mina Pribbenow

La Loma is second biggest coal deposit of Colombia and is diminished by the big coal Drummond Comp. Inc. Already in the 1980's the U.S. group Drummond acquired the rights
the mining of Mina Pribbenow/La Loma. The development starts in the 1990's years. The coal of Mina Pribbenow owns a good quality which has a ash content of 7.7 % and the sulphur content amounts to 0.61%. The reserves are about 450 Million t and the production amounted in 2003 about to 12.5 Million t. Also in Mina Pribbenow near of La Loma the top soil is cleared up and blown up at harder places of the rock. In the following the rock material is taken away. Afterwards the coal is transported by means of bulldozer mechanically and is loaded onto cargo trains. Mina Pribbenow disposes of a 210km long freight railway line which is available exclusively for the transport of the coal extracted there. This railway line transports the coal of the mine directly to the harbour of Cienaga/Santa Marta where it will be loaded directly into vessels. The relief of the carbonaceous area is very wavy with hills of a low height. The area has an elevation between 140 and 330 m NN. Valleys of low depth consists of grassland. The fertility is low.

La Jagua

La Jagua is the third biggest coal deposit of Colombia and is in the region Cesar. The reserves amount to about 258.3 Million t and in 2003 the production was about 8.5 Million t. The coal quality is good, the ash content is about 5.32% and the sulphur has about 0.62%. La Jagua has fourteen beds and a size of 24 km². As well as already at Mina Pribbenow the top soil is cleared up and blown up at places with harder rocks. The coal is transported by means of bulldozers and loaded in the following on cargo trains which transport the coal to the harbour of Cienaga/Santa Marta. The structures in the area around Jagua are characterized by anticline and syncline folds and by the appearance of faults. The tectonic situation is not complicated and none of the flanks of the syncline of Jagua is influenced by greater faults. Regional faults became known only with the mining of the coal deposits; however, these are less interesting. The layers are generally steady; this appears very clearly in the opencast mining. The provinces Cesar and La Guajira produce more than 92% of the minable coal reserves in Colombia.

Galca

The initial focus has been to apply for concessions close to existing coal operations. Thus far, Galway, has applied for concessions in Cesar, directly adjacent to existing coal operations with existing infrastructure. Additionally, after extensive geological work the Company has also identified a new area, named "GALCA".

Fig.5: Galway’s Concessions; http://www.galwayresources.com/s/ColombianCoal.asp#
The location of GALCA basin is between the towns of Aguachica and San Alberto in the province of Cesar. There’s a railway line intersecting the property and adjacent to the Magdalena river where coal is also transported. The management believes this new area has the potential of being a new thermal coal basin in Colombia. The Coal potential of GALCA is estimated to be of 30 - 100 million tons in each of the two sub basins forming GALCA using a minimum thickness of 40 meters and ten kilometers strike length. The resource potential could be as large as the resource at the existing in La Jagua Basin. The anticipated coal quality is also comparable with La Jagua basin with less than 0.6% sulphur. Galway submitted concessions for 333,500 hectares in the GALCA area during October, 2007. It’s developing Phase I exploration in the area that has a significant amount of historical seismic surveys and drilling data to be completed by February 15th, 2008. Phase II and subsequent drilling program to be developed in the second half of 2008.

Provinces with smaller coal deposits

Cundinamarca

The province of Cundinamarca in the centre of Colombia exported in 2003 about 1.5 Million tons of coal. The basic mass of this tertiary coal is vitrific coal, but duritic components are also included, these duritic components lead a lot of plant material as spores, cuticles and cork material. Therefore the duritic components are formed of bark fragments, wooden parts, spores, resin fragments and rests of herbaceous plants. A clear wooden structure is to be recognised, this shows that the coal is originated of wood. The vitrific stripes are thin and have only a low extension, so the coal is not originated of thick wooden trunks, but rather of thin branches and similar ones. Fusit is included only in small amounts and the single layers of the coal are compressed and bulged, nevertheless, do not run in parallel (REICHENBACH, 1928).

Boyacá

The province of Boyacá exported already in 2003 about 1.9 Mil. t of coal. It’s a tertiary hard coal with duritic, vitrific, and some fusitic parts. The coal owns few bitumen bodies, broken cork fabric knows on bark leftovers. Epidermises, wooden leftovers, fabric parts and spore skins are well-preserved and the origin material of the coal is primarily wood (REICHENBACH,1928).

Santander

The coal is duritic and owns many Vitrinite layers. The coal is rich in cuticles, pollen, spore grains and bitumen body. Fusit appears here and there in nice wooden structures or cell structures, often also smashed (REICHENBACH,1928).

North Santander

The North Santander province exported in 2003 about 1.6 Million tons of hard coals, this has a fatty shine, is very thick and friable. It contains much vitrific material, many scraps of cuticles, spore grains and bituminous bodies, this causes partly the high gas production rate of the coal (REICHENBACH,1928).

Problems of the coal mining

With comparisons of the resources with the present mining strikes that the coal mines cannot use the full capacity, among the rest, this is caused of the special climate of the country. Colombia is influenced by the north-east trade wind, which causes the origin of dry regions. The northern part of Colombia is an area of the highest temperatures.
The climate is marked in general by the appearance of a dry period from January to August, which is followed from September till December by a rainy period. The precipitation mostly falls as a strong rain, or in the form of the cloudburst which can lead to floods in the foothills (VÁSQUEZ, 1928). The opencast mining pits are also concerned by these floods, they run with water fully and do the dismantling impossibly. Therefore it comes at regular intervals and involuntary interruptions of the dismantling during the rainy season. Partially the production stands still for days, this signifies immense losses for the companies. But to reduce this by pumping off the opencast mining pits also beginning attempts, fail because of the big water masses. Another problem shows the hardly developed infrastructure. Colombia disposes only of a low number of asphalted streets. These streets are damaged by the coal transport trucks. Four good railway lines are stretching straight through Colombia up to the single harbours, are available exclusively to the big coal companies. A substantial removal of the Colombian harbour capacities is necessary beside the expansion of the railway system also. This extensive infrastructure work are already in planning, but with the tempo of the present negotiations still some time will pass up to conversion. In addition to the problems mentioned above which hinder the coal mining; is the fact that the state is not able to control all regions. The Department Cesar in the north of Colombia is one of the regions strongest controlled by paramilitary groups. This community is against the foundation and the entry the worker to trade unions which fight for more wage and better terms of employment. It comes for dismissals, pursuit and murders of trade unionists by paramilitary groups, also to intimidation of employees. Only the politicians working for the paramilitary groups could stand for the election, there are huge electoral fraudulences and the murder of unpleasant candidates is in the agenda.

All these problems should be removed bit by bit, but the government will still probably need some years, until the coal mining can use its full potential without impediments.

Environmental impact and the health of the population in the area of the coal opencast mining

Beside the explosions which break up the coal layers, above all, the massive truck traffic influences the surrounding villages. To hundreds the trucks stand before the mine queue to drive the coal to the harbour. Because the trucks use the same street like the inhabitants of the villages and the mine workers and these are not tarred, the streets are in very bad state. Not only the dust whirled up by the truck, but also the coal dust of the uncovered loads and the coal dumps beyond the mine impairs the health of the people in the surrounding villages. The population suffers from breath way illnesses and lung illnesses and complains of odour nuisance, constant influenza symptoms with the children, skin rashes and irritated eyes. Many trucks transport the coal from the mines to the harbours and wait in the villages for the loading. The consequences are massive environmental pollution, noise pollution, destroy the streets and result in high rates of accidents. The existing harbours for the shipment of the coal show another big environmental problem. Because the Bahia Bay is not very deep, the big tankers must anchor outdoors on the open sea and will load with small transfer vessels. On the one hand this leads to a visual interference of the sea and the beaches; on the other hand, coal gets lost while reloading and dirties water and beaches. The mining interrupts or seals rivers which supplied the villages before with drinking water and leads the water in the mine. There it is used to the purge of the coal and to the cleaning by devices and carriages. In the following the water is escorted unclean in the surrounding brooks by which it becomes inedible. Also the massive water consumption leads for drying up of many brooks and the ground-water levels sinks.
During the rainy season heavy metals from the stockpiles are washed out and contaminate surface watercourses, as well as the ground water. The pastures which are flooded periodically are not usable because of the soiling any more. Therefore there are many losses with the cattle breeding. Also the people depend by the soiling of the rivers on ground water and must pump this from bigger and bigger depth what signifies another financial load for the population (VÁSQUEZ,1978). By the massive clearing of the trees which leads to the erosion and to the siltation of the water the soiling aggravates, in addition.

The companies are obliged by contract to afforest the exploited areas to renaturation and, 15 years are with it, nevertheless, already in the remains and will not be able to make up for this, unfortunately, again. Also expelled inhabitants, the already destroyed villages wait for many years for the compensation which they are never got maybe.

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