

Sessions

of IAG 1999 Regional Conference on Geomorphology

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2. Tectonics and Landscape Evolution
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Abstracts **delivered at IAG 1999 Regional Conference on** **Geomorphology**

SESSION: Fluvial Geomorphology

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Abstracts - Sandra Baptista da Cunha and Antonio Jose Teixeira Guerra (Eds.)

FAN SYSTEMS IN SWAMPLANDS OF MATO-GROSSO STATE-BRAZIL

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Brazilian Matogrossense swamplands (Pantanal Matogrossense) are a plan, lowered, swampy surface of 138-183 Km², inside high Paraguay basin on west centre region of Brazil. It encompasses partial areas from Mato Grosso (MT) and Mato Grosso do Sul (MS) States. Paraguay river and tributaries control typical pattern forms: fragile fluvial dikes, floodplain lacustrine forms and extensive fluvial fans. Sub-basin surfaces connect themselves water, sediments, nutrients during main flood periods (from November to March). Between Descalvado (MT) and Corumbá cities (MS), along Brazil/Bolivia border (north-south direction), there is a depression zone (bajada), on quaternary sediments between fans, with extensions along downstream from tributaries Corixa Grande, and Cuiabá (MT State); Taquari, Negro, Miranda (MS State). These drainage control fans and define their floodplain over bajada's zones resulting in residual lakes, oxbow lakes, terraces, flood plains and abandoned dikes. Singular drainage pattern occurs on variable superposed directions and meandering channels inside silted braided plains. They reflect successive regional structures and flow regime changes. There is a new fan of Paraguay River, between Descalvado and confluence of Cuiabá River (alluvial material).

Extensive fans are constituted by sediments from Pantanal Formation, distinct period of flooded duration between themselves and on their segments higher to interior. There are alluvial-coluvial cones of 'piemont' around fans, near high relieves. Fans are in construction process, over local depressions, through flood plain expansions.

Artificial changes of channel, on fluvial-lacustrine environment in formation along Paraguay River, become inappropriate with insufficient studies and legal preservation areas: Taima Biologic Reserve and Matogrossense National Park, with archaeological sites around Descalvado and Taima Isle, for example. It is necessary much attention on monitoring Paraguay fan area.

THE GEOMORPHOLOGY OF THE TAQUARI RIVER IN THE PANTANAL, BRAZIL

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Pantanal is an alluvial lowland region in western border of Brazil. The Paraguay is the trunk river of a depositional system tract composed of several humid alluvial fans. The Taquari alluvial fan, the most conspicuous among them, is a giant wet system with circular geometry and 250 km in diameter. Its altitudes varies from 160 m at the fan apex to 100 m at the fan toe (gradient of 24 cm / km).

The present channel system is slightly entrenched in the upper fan. Here, the Taquari River is a meandering channel and sedimentation occurs in a confined meandering belt. This pattern changes downstream as a consequence of progressive narrowing of the meandering belt, as well as decreasing of sinuosity and height of terraces.

In the middle fan the system acquires a radiating distributary pattern. Many points of avulsion, progradation and abandonment of crevasse splays are visible in satellite images. The water discharge decreases downstream mainly by avulsion and secondary by infiltration and evaporation.

Active avulsions and anabranch confluences characterise the distal part of the river, where the active fan lobe is being constructed. Multitemporal analysis using satellite images, obtained in the last 30 years, revealed abrupt changes in the river course. The main avulsion point, called "Arrombado Zé da Costa", is nowadays responsible for 70% of discharge, shifting the Taquari main course.

Avulsion and shifting are natural phenomena in the evolution of the Taquari alluvial fan, but are now accelerated by human occupation. Agricultural activities have increased erosion in the drainage basin and sediment input to the alluvial fan. In consequence, the Taquari River is being rapidly filled up with sands, causing shallowing and navigability problems, triggering avulsion and enlarging floods in the lower fan.

MARGINAL EROSION AND LANDUSE IN THE PEIXOTO RIVER BASIN - PRATA - BRAZIL

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The Peixoto River Basin is located in the municipal district of Prata in the state of Minas Gerais. The area in question is within the morphosculptural group denominated The Triangulo Mineiro Residual Relief Area. The morphosculpture is characterised by the relief testimony in the form of mesas and plateaus, with great cliffs, having at their bases detritus deposits and wide, colluvial ramps. The declivity varies between 7° to 15° on the ramps and between 30° to 90° in the cliff areas, with altitudes of between 600m to 650m.

The present study, starting from the perspective of georelief, takes into consideration the geomorphologic analysis along with anthropic performance in the area leading to the disruption of the systemic balance of the landscape.

The accelerated processes of erosion are evidence of the instability of the landscape which, over the last 100 years has been experiencing man's direct action, having practically the totality of its vegetation replaced by pasture land destined for the purpose of raising cattle. The substitution of the savanna for pasture land together with the continual stamping of the ground by cattle consequently compacted the soils, adding significantly to the runoff of the pluvial waters. In this way, the speed of flow and the discharge accompanying torrential pluviometric events, characterised by its high energy potential, can affect the whole transversal profile of the fluvial gutter. Most of the channels possess intermittent segments that dry up during the prolonged dry period (May to September).

As a result, the marginal erosion processes of the drainage channels in the Peixoto River Basin set off in the last two years are striking, evidence of which has been the continuous receding of the banks, accumulation of sand in canals, waste deposits in the valleys and the jeopardizing water resources.

GEOMORPHOLOGICAL ANALYSIS OF THE SAO MIGUEL BASIN, JEQUITINHONHA VALLEY, MINAS GERAIS

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A basin in itself is a fundamental study unit to recognise morphogenetic processes. Geomorphologic analysis was used to provide information about the basin characteristics, and to understand the landscape evolution. Sao Miguel River is one of the principal tributaries of middle Jequitinhonha Valley. This basin is located between 16°25' and 16°52' southern latitude and 40°45' and 41°16' western longitude. The basin has 2,200 km² surface, which contains in itself two different component landscapes, strongly related to the geological structures. The first component, at the eastern part of the basin, belongs to the Jequitinhonha Depression, which presents a well defined stream-channel network along a range of flatted forms. The channel-network on this first component has a medium drainage density and a marked dendritic drainage pattern, E-W direction. The altitudes in this area range from 600m to 900m. It is characterised by flat hills, flat valleys and numerous occurrences of granite domes, formed under conditions of strong chemical weathering. The western part of the basin, corresponding to the second component, belongs to the geomorphologic unit of Jequitinhonha Plateau. It shows flat surfaces known as "chapadas" with average high of 500 m and maximum altitudes of 900m. This is an area highly dissected, with a high density channel-network, dendritic drainage pattern and SE-NW direction. The component's valleys are entrenched, and slopes quite steep. There exists large accumulations of corestones at the Sao Miguel's river course, as well as on lower slopes around the massive domes, probably, settled there by gravity.

RIVER STYLES: A GEOMORPHIC TEMPLATE FOR ANALYSIS OF BIOPHYSICAL PROCESSES ALONG RIVER COURSES

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River styles provide a geomorphic summary of river forms and processes within a reach. Assessment of river style is determined by channel geometry (size and shape), channel planform, and the assemblage of geomorphic units that make up a river reach (in both the channel and floodplain zones). Analysis of the character and condition of river styles entails three stages, namely baseline survey of river character and behaviour within a catchment, assessment of river condition, and prioritisation of management efforts at river conservation and/or rehabilitation. The river styles procedure has been trialed in various sand- and gravel-bed coastal river systems in New South Wales, Australia. There are no obvious reasons why this approach to catchment-framed analysis of river geomorphology could not be applied to river systems in any geographic setting.

River styles are analysed within a nested hierarchical approach, showing the linkage of biophysical processes at catchment, landscape unit, reach and geomorphic unit scales. The character and behaviour of river styles are conditioned largely by the landscape units (or topographic setting) through which rivers flow. Distinct downstream patterns have been identified, showing changes associated with valley width and stream power. Individual river styles comprise mosaics of channel and floodplain geomorphic units. Downstream patterns, evolutionary trends, and the relative condition (and recovery potential) of differing river styles form a biophysical basis for prioritisation of management efforts at river conservation and rehabilitation.

The geomorphic context within which river styles are analysed provides a basis to assess habitat availability along river courses. As such, changes to the geomorphic structure of rivers have direct implications for the range, extent and connectivity of habitat. These considerations are analysed through assessment of the condition of each reach of each river style. In recent work, this framework has been extended as a biophysical platform to assess the impact of differing water allocation strategies along river courses, through designation of representative sites for catchment-wide monitoring programs.

ASSESSMENT OF SEDIMENT DELIVERY RATIO IN LOESS PLATEAU, CHINA

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The sediment delivery ratio is a crucial factor in conducting research in soil erosion and sediment yield relationship. Most previous research only focused on the topography as well as other environmental influence on the sediment delivery ratio. Many researchers compared its difference among drainage basins.

Experimental results at Yangdaogou, a tributary of the Wangjiagou drainage basin in the Loess Plateau, China, indicate that the range of sediment delivery ratio changes with time. Based on the data collected from 1963 to 1968 at Yangdaogou, the calculated long-term average sediment delivery ratio was close to 1.0. Due to temporary storage and re-transportation in the bottom of the gully, inter-annual sediment delivery ratio ranged from 0.36 to 1.12. The range of storm sediment delivery ratio was between 0.36 to 1.85. According to the X² test, the frequency of storm sediment delivery ratio followed a normal distribution N (1.02, 0.38). The mean, median, and mode were all around 1.0. Other frequency of sediment delivery ratio for each storm can be calculated by the following probability function:

$$f(Y) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{Y-\mu}{\sigma}\right)^2}$$

Correlation analysis between 11 causative parameters and the storm sediment delivery ratio showed a significant power function relationship. The regression equation of storm sediment delivery ratio can be expressed as:

$$SDR = 0.0277R^{-0.29} C^{0.19} Sm^{0.59} (E_w/E)^{0.44}$$

This equation has both a very high correlation coefficient and explicit physical meaning. Besides, the four selected parameters can be easily obtained from field experiment stations. Calculation of storm sediment delivery ratio based on this equation for more than 20 events between 1963 and 1968 have attained a very high degree of accuracy as compared to the field data. It is feasible, therefore, to use this equation to predict the storm sediment delivery ratio and to explain in some degree the mechanism of sediment delivery at Yangdaogou.

THE ANTONINA AND PARANAGUÁ BAY'S REGION, BRAZIL: ENVIRONMENTAL ZONING

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The Paraná State coastland, located at the Brazil's southern region, have several special areas as the shore zones, ecological reserves, protection areas as well as and tourist special reserve areas. Therefore, the objective of this communication is to present the environmental zoning of the influence area of the Antonina and Paranaguá bays, situated on the northern coastal zone of the Paraná state. The researched area is between 25°00' to 26°00' South Latitude and 48°15' to 49°00' West Greenwich Longitude, pertaining to the Antonina, Morretes, Paranaguá and Pontal do Paraná counties. The environmental zoning methodological approach have considered the relief patterns and the geomorphologic properties of the drainage basins. These elements were correlated with the geological properties, vegetation, terrain declivity and soils. Twenty nine drainage basins have been studied, whose hierarchy varied from 3rd to 6th Strahler's order. The analysis carried out confirmed that some parameters of the drainage net obey the Horton's law regularity pattern for mountains or coastal zone models. The geomorphic analysis showed to be possible delimiting the follow environmental zone: mountain zone, coastal plain zone (sand bar plain and flood plain), and Mangrove zone.

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THE JOÃO FERREIRA CREEK, UPPER RIO DOCE BASIN, MINAS GERAIS, BRAZIL: AN EXAMPLE OF COARSE-GRAINED MEANDERING RIVER

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The João Ferreira Creek, flows through around 7 km at the right side of Piranga River (upper Doce River). Along its course, this creek cuts its older deposits, cutting terraces up to 20m high. In the scarps of these terraces it can be identified sedimentary facies that show the changes that occur in this creek through times. At the feet of the scarp of the older terrace sandy, pebbly sand and gravely facies occur. These facies are usually related to braided rivers. To the upper part of this scarp the facies change to sandy and muddy facies usually related to meandering rivers. All other terraces have sandy to gravely facies in their scarps.

The João Ferreira Creek shows internal and point bars, both types formed by sandy and gravely facies. Usually, more typical shaped point bars are located upstream of the gorges that are formed when schists from the basement outcrop at the channel level. Point bars show interlayered sandy and gravely horizontal or quasi-horizontal strata. Gravely strata usually have clasts that show their ab plane with no dips. Sometimes, gravely strata are irregular in shape and seem to be developed by the deposition of gravels upstream or even around the outsized clasts, usually boulders.

This research, still in development, suggests that the great number of boulders and gravel in this creek be due to the release of them from the terraces. Nowadays, the lack of competence by this creek in moving gravel and boulders as bed-load transport until reach the Piranga River is responsible for this unusual coarse-grained meandering river aspect.

EVOLUTION OF THE RIVERS SECCHIA AND PANARO IN THE PO PLAIN IN THE 19TH AND 20TH CENTURIES (MODENA PROVINCE, NORTHERN ITALY)

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The Rivers Secchia and Panaro are the main rivers of the Modena Province. Their Po plain stretches (about 100 km and 85 km long respectively) have two sectors whose geomorphological characteristics are different; in fact the rivers, near the Apennine margin, are deepened in the alluvial plain while, in the mid-lower part of the plain, are hanging rivers within artificial levees.

This study was based on detailed bibliographical research, examination of historical documents and maps, interpretation of aerial photo-interpretation and field survey. From the first millenium B.C. to the 14th century A.D. the Rivers Secchia and Panaro wandered within a rather wide area. Courses very similar to the present one were taken by the rivers in the 14th-15th centuries, after several diversions.

As regards the evolution over the past two centuries, near the Apennine margin the rivers turned from a braided riverbed to a channelised course subject to marked deepening. This modification was due to the gravels quarrying activities along the riverbeds (particularly intense since the 1950s) and the construction of fluvial barrages. In the mid-lower part of the plain, the rivers course have been conditioned by artificial meander cuts carried out to reduce flood hazard. The R. Secchia meander cuts, carried out mainly in the mid-19th century, have shortened the river length by about 10 km; the R. Panaro meander cuts, carried out at the end of the 19th century and in the beginning 1970s, have shortened the river course by about 8 km. Since these cuts did not reduce adequately flood hazard, "flow regulation systems" were constructed in the area of Modena along both rivers.

It can be stated that the present courses of the Rivers Secchia and Panaro in the Po Plain are the result of a series of anthropogenetic interventions over the last centuries.

BRAZILIAN RIVERS: IMPACTS OF RIVERS ENGINEERING AND THE POTENCIAL FOR RESTORATION

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This paper analyses the impact and degradation of some Brazilian large rivers as Paraná, Tocantins, São Francisco and Teles Pires rivers, showing the need of restoring their natural characteristics and floodplain.

Restoration of large rivers has been practised in some countries. The experience of Germany, United State, United Kingdom and Denmark are important examples. Restoration of large rivers in the sense of the return to the original condition is still a big challenge because it is extremely complex, expensive and the background to predict success or to monitor recovery is little (Gore and Shields, 1995).

In Brazil, both regulation and channellization have modified channels. As in other parts of the world, these experiences have destroyed or degraded most river environments and the fish and wildlife habitats once provided by the rivers and their floodplain wetlands.

River regulation has been applied to hydroelectric power generation and the country has around 65 rivers regulated by plants above 10MW. Hydropower is the main primary source of renewable energy (62.07%) followed by wood (21.39%) and sugarcane (16.53%).

River regulation has been implemented in relation to both large and medium-size rivers. The Southeast and South of the country are the main areas of regulated rivers because they are the principal developed areas of the country and have good environmental conditions, including favourable land and rivers inclination. These areas include the large Paraná River and its tributaries, some secondary rivers that run to the Atlantic Ocean and the headwater of São Francisco River. A small number of rivers have been regulated in the Northeast of the country and only recently, towards the end of the 1970s and 1980s, has the government tried to produce hydropower energy in the north of the country. Included in these projects are the large Tocantins and Tapajós rivers and the medium-size Curuá and Ji-Paraná rivers.

River channellization has been effected in many lowland rivers for the proposes of irrigation projects, flood protection (rural and urban areas) and to improve the health of the population by doing away with malaria and yellow fever. All the main lowland rivers in the Northeast and Southeast of the country were channellized during the 1970s and 1980s and recently, agro-cattle-raising projects have led to some rivers in the centre-west of the country, such as the Araguaia and São Lourenço rivers, being channellized. Rivers in the Amazon basin have been protected from channellization.

DISSECTION PATTERNS AIDING GEOLOGICAL MAPPING OF THE LOWER SOLIMÕES REGION - AMAZON

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Fluvial landforms were analysed at regional scale in terms of their dissection, channel patterns and other geomorphic features to give support to geomorphological and geological mapping of central Amazon. The confluence region of Japurá and Solimões rivers and 200km downstream were studied using remote sensing (Landsat Thematic Mapper images, radar mosaics, 1:250,000), hydrological map and also considering the information from RADAM project maps. This area has been recently reinterpreted for SIVAM project and requires a high number of scenes due to its dense rainforest cover and persistent clouds.

The Lower Solimões and the Japurá rivers develop a wide Holocene floodplain that crosses two sedimentary units of the Solimões basin. On its north western to south eastern course, Solimões changes from meandering to braided pattern and cut Tertiary sediments of the Solimões Formation on the right margin, and Pleistocene sediments identified as the Içá Formation on the left margin. The first one can be identified based on its dissection pattern with a relatively high drainage density. The drainage network is neotectonically controlled and two main directions of the streams were observed: NE-SW for the main channels and lakes, and NW-SE for the secondary channels.

On the north eastern region, on the left margin, a reworked surface texture on image reveals a dissection pattern with a lower drainage density, also presenting linear segments on its drainage network. The W-E and NW-SE directions mark a recent morphotectonic evolution printed on the rivers. In addition, Pleistocene sediments show old meander scrolls and paleochannels as common geomorphic features easily observed on images.

The remote sensing data is being extremely useful under a mega-geomorphology perspective, enabling strong associations between the dissection patterns of the Lower Solimões region and their lithological units.

A PRELIMINARY STUDY OF THE CHANNEL NETWORKS STRUCTURE OF A FIRST-ORDER DRAINAGE BASIN, WESTERN PARANA STATE, BRAZIL.

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Field surveys were carried out between March to August 1998 to determine the drainage channel networks structure of Meurir stream, a first-order basin located in Marechal Cândido Rondon county, Paraná State, Brazil. The stream has a basin of 0.36 km² and elevations vary from 350 to 410 m. The regional terrain is rolling to flat. The basin is predominantly rangeland and farms. The area is underlain by cretaceous tholeiitic basalts. The region has a subtropical climate with a average annual precipitation of about 1,200 mm. Channels length were mapped in the field with Brunton compass and sources locations were made bi-weekly onto the basemap. These records were employed to determine the extent of the channels types. The total length of drainage network in the study basin are 974 m. Perennial channels constitute 324 m (33.3 %), intermittent channels 349 m (35,8 %) and ephemeral channels 300 m (30,8 %). Field observations show that extent of channel flowing vary systematically with precipitation. For example, in August 23, heavy rainfall (60 mm) have caused rapid upstream migration of sources. After some hours, the length of channel flowing increases from 142 m (end point of perennial segment) to 428 m (end point of intermittent segment). The relationship between extent of stream flow and the discharge is very close. Stream discharge was monitored in the perennial segment and varied from 0.045 (July 25) to 19.530 l s⁻¹ (August 23). This study have revealed a particular structure of channel system in humid environment and variations in the length of channel flowing in a short period.

GEOMORPHIC APPROACH TO IDENTIFICATION OF RIVER RECOVERY POTENTIAL: APPLICATION IN BEGA CATCHMENT, SOUTH COAST, NSW, AUSTRALIA

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River recovery occurs naturally as rivers adjust to disturbance. While many studies of river character and behaviour have documented pathways of degradation (i.e. river metamorphosis), few studies have assessed the character, capacity and stages of river recovery. In this paper, a generic procedure to analyse river recovery is developed and applied in Bega catchment, on the south coast of New South Wales (NSW), Australia. Historical data and field analyses are used to identify stages of river evolution throughout Bega catchment. From this, stages of river condition and pathways of adjustment are assessed for three river styles at different positions within the catchment. The approach, which is based on a geomorphic unit frame, and invokes principles of ergodic reasoning, directly links river forms and processes at various stages of recovery. To differentiate among the various recovery pathways for each reach of a river, and assess the potential of that reach to recover, two basic requirements must be met:

- Detailed and fully documented evolutionary frameworks of river change
- Appreciation and understanding of geomorphic linkages within a catchment, and associated limiting factors which may inhibit recovery potential.

One degradation, and two recovery pathways have been identified. Reaches falling along the first recovery pathway are adjusting back towards a restored condition, and those falling along the second are adjusting towards a new (or creation) condition. The former is possible where rivers have proven remarkably resilient to change. The latter occurs in catchments in which the boundary conditions (i.e. water and sediment transfer and riparian vegetation and CWD loadings) have been fundamentally changed and hence river character and behaviour has been irreversibly altered.

While it is recognised that rivers adjust along an evolutionary continuum, whereby reaches of the same river style display different conditions, in simplistic terms, snapshots along the evolutionary sequence are used to describe different stages along the degradation and recovery pathways. To simplify the analysis, five stages of river condition have been identified: intact, degraded, turning point, restoration and creation. Intact reaches operate in a self-adjusting manner, whereby processes maintain the pre-disturbance geomorphic character of the reach. The processes occurring in restoration reaches maintain and enhance the geomorphic structure of the reach. These reaches are moderately resilient to change. Turning point reaches can recover or revert to a degraded state. Degraded reaches are often still adjusting to disturbance and the processes of recovery have not yet begun and a creation reach has a self-adjusting character and behaviour but operates under altered catchment boundary conditions (in terms of water and sediment transfer). Once identified, each reach is placed on pathways of degradation and recovery, and predictions made about their direction of change. The approach provides a solid basis to identify appropriate target conditions for river rehabilitation based on the natural variability in river structure and flow, and the natural character of rivers in equivalent landscape settings. In addition, it provides a geomorphic platform to assess the ecological recovery potential within a entire system.

DAMS, SAND-MINING AND SEDIMENTS - A BUDGETING APPROACH FOR MGENI ESTUARY NEAR DURBAN, SOUTH AFRICA

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Demand for building sand remains high in the Durban region, although one of its main sources, the lower Mgeni River, is threatened by Inanda Dam. Completed in 1988 at a site some 32 km from the river mouth, the dam may have influenced bedload transport and deposition. The aim of this study was to ascertain whether the dam had affected fluvial sediment delivery to sand extraction sources below the dam, and to predict the likely affects of continued sand mining on the Mgeni estuary. Bridge construction and canalisation of a section of the lower river reach have all influenced the river in recent decades, and the situation is further complicated by a huge flood in 1987.

Re-examination of estuarine cross-sections originally surveyed prior to dam completion, comparison of current estuarine sediment characteristics with those of pre-dam sediments, and a bottom survey of the Inanda Dam itself were key elements in the analysis, conclusions and future predictions .

Mean annual discharge of the Mgeni river is estimated at 323 million m³ per year, and the best estimate of annual sediment load, calculated from repeated bottom surveys of Inanda Dam, was 6,8 million tonnes. Tributaries entering the river below the dam, which together drain 8,9 % of the total catchment, could yield up to 600 000 tonnes per year. Up to 1982 about 800 000 tonnes of building sand was being extracted from the river annually, but by 1987 this figure had fallen to 130 000 tonnes.

The study concluded that combined effects of the engineering modifications to the river, the 1987 flood and sand mining have changed the nature of the sediment and the estuary considerably. Continued extraction of sand even at low levels will result in estuarine scouring and a new equilibrium form probably within a decade. Complete cessation of sand mining will delay this, but long term scouring will still occur, meaning that future plans for estuarine management must take account of physical dynamism within the system.

MORPHOLOGY, DRAINAGE AREA AND FLOW RELATIONS FOR BAHIA'S RIVERS

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Some characteristics of river morphology depends on flow and relations have been established (Cristofaletti, 1981). Besides this, the flow is influenced by the basin physical conditions, such as drainage area, topography, ground cover and use. Furthermore, the basin area is one of the most important factors on the data transfer of regional flow hydrological studies (e.g. Chow, 1964; Tucci, 1993).

Based on streamflow station field surveys and cartographic data analysis, this work presents relations derived for two morphological river parameters (main river length and cross section width) as a function of basin drainage area for different regions of Bahia. The relation between flow and drainage area is also presented.

As a result the equation like $Y = a A^b$ showed good fit to the data. The relation between main river length (L) and drainage area (A) was the best one. For different regions a and b have changed. For example, the Paraguaçu River that runs to the Ocean and has headwaters in Chapada Diamantina resulted in the equation $L = 1,175 A^{0,555}$, while the Corrente River Basin, which runs over a sedimentary plateau, left margin of São Francisco River, resulted in $L = 16,44 A^{0,287}$.

The relations between the maximum discharge and drainage area were best fit to perennial rivers rather than intermittent ones.

RIFFLE-POOL LANDFORMS AND FLOOD HISTORY IN A DESERT GORGE, AUSTRALIA

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Some characteristics of river morphology depends on flow and relations have been established (Cristofaletti, 1981). Besides this, the flow is influenced by the basin physical conditions, such as drainage area, topography, ground cover and use. Furthermore, the basin area is one of the most important factors on the data transfer of regional flow hydrological studies (e.g. Chow, 1964; Tucci, 1993).

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As a results equation like $Y = a A^b$ showed good fit to the data. The relation between main river length (L) and drainage area (A) was the best one. For different regions a and b have changed. For example, the Paraguaçu River that runs to the Ocean and has headwaters in Chapada Diamantina resulted in the equation $L = 1,175A^{0,555}$, while the Corrente River Basin, which runs over a sedimentary plateau, left margin of São Francisco River, resulted in $L = 16,44 A^{0,287}$.

The relations between the maximum discharge and drainage area were best fit to perennial rivers rather than intermittent ones.

STREAM SOLUTE RESPONSE IN THE SMALL POST-GLACIAL CATCHMENT, WEST POMERANIA, POLAND

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Studies of the water circulation and leaching are usually carried out in mountainous and upland areas with thin layers of skeletal soil and the river discharge controlled by the overland flow, throughflow, or flow from shallow groundwater. The results presented in this study are representative of postglacial environments with highly variable geological structure, permeable deposits, thick soil profiles, and high retentiveness of catchments. These conditions alter fundamentally the time and pathways of water circulation, the spatial and temporal variability of fluvial transport, and also the intensity of denudation.

The various forms of feeding a river channel, together with the availability of dissolved substances, are of fundamental significance for the time of material supply from the catchment to the river channel as well as for the magnitude and dynamics of transport. The aim of the present study was to gain an insights into the nature and dynamics of the flow of dissolved substances in an environmentally heterogeneous postglacial catchment.

The field research was conducted in a small catchment drained by the Kluda River, Poland. This is a part of the upper Parseta hydrographic system, which is considered to be representative of the postglacial lakeland zone of West Pomerania and the Polish Plain. The study is based on hydrological and hydrochemical data from the period 1990 - 1993. Hydrological measurements carried out at a water-gauging station located on the 6.5th kilometre of the Kluda. The variability of solute transport was determined on the basis of 83 periodic measurements taken in the water-gauging profile closing the Kluda catchment. Temporal changes in the concentrations of selected chemical parameters of the Kluda river were used as natural geochemical indicators of variability of chemical denudation processes in a postglacial catchment in the temperate zone.

The periodic observations of the physico-chemical parameters of the stream water show low variability of total mineralisation and the concentration of ionised silica as well as calcium, magnesium and bicarbonate ions. The slight changes in the concentrations of compounds dissolved in the stream water indicate that in the range of discharge registered during the research it is fed predominantly by groundwater. The high permeability of deposits, retentivity of the substratum and mineral-organic deposits with a high groundwater level make it easy to "push out" the water present in the catchment before precipitation, i.e. the "old" water.

In a catchment of low relief, with deep soils and important role of groundwater flow like the Kluda catchment, only a small proportion of the variance in concentration may be explained by discharge. The high retentiveness of the catchment system explains the absence of direct links between the magnitude of precipitation, the discharge, and water chemistry in the river channel. The concentration - discharge relationships over long periods may be also obscured by seasonal fluctuations due to biological or geochemical processes. Other factors that may control those relations include:

- seasonal variations in ion concentrations resulting from their role in the biological cycle;
- the chemical composition of precipitation water and the activation of dry deposition;
- the feeding by water from the overland flow and throughflow, since it is enriched with compounds coming from short-term and seasonal washout of salts;

effects of hysteresis which often explain why the connection between the ion concentration and the discharge is absent or only loose, especially when we deal with seasonal measurements that do not embrace entire flood events.

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ANALYSIS OF THE USE OF THE SOIL IN DIFFERENT GEOMORPHOLOGICAL/LITHOLOGICAL COMPARTIMENTS

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The Piraputanga basin (170,82 km²) is located in Southwest of Mato Grosso State, Brazil. The main river (Piraputanga River) drains to the left margin of the Paraguay River and the sources of the tributaries rise in the Mountainous Province (680m).

This study aims to analyse the soil use in the basin, from 1968 to 1997, in the 5 geomorphological / lithological compartments.

The compartments division was made using topographical maps (1:250.000), satellite image LANDSAT 1990 (1:100.000, bands 3, 4 and 5) and studies published by RADAMBRASIL (1982). The analysis of the soil use was made from aerial pictures of 1968 (1:60.000/USAF) and satellite images of 1990 (1:100.000/LANDSAT) and 1997 (1:50.000/LANDSAT, bands 3, 4 and 5).

The results showed that in the anticlinal valley, with limestone, occurred a reduction in the gallery and tropical forests, due to deforestation for the production of vegetable coal and to the expansion of the pasture. In the anticlinal valley with borders sculpted in sandstone it was totally occupied by pastures, going up the hillsides in some points. In some places the subsistence cultivation was preserved. In the synclinal valley in shale and siltite significant changes have not occurred, however, the deforestation and the highway MT 126, among other factors, provoked erosion creating gullies and rills. The largest modifications in the use and occupation of the soil happened in the depression in sand-clay sediments, due to the expansion of the urban area, construction of the airport, besides the increase of the pasture. As a consequence it was verified the reduction in the gallery forest, in the tropical forest and in the farming. In the floodplain in fine sediments, the change was related to the substitution of the natural pasture for cultivated pasture, reducing the valley forest.

THE CONTRIBUTION OF THE FLUVIAL SEDIMENTS IN THE GEOMORPHOLOGICAL EVOLUTION OF THE JACAREPAGUÁ LAGOON, RIO DE JANEIRO

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The presence of barrier islands along coasts determines a change of processes, where the areas of the marine sedimentation begin to receive sediments, which tend to be from continental origin. Thus, coastal lagoons begin to work like "receiver tanks" of the waters that drain adjacent coastal plain and ranges that delimit its drainage basin and consequently its hydro-sedimentological contribution area. The water like a connectivity element between natural systems, works carrying inputs and outputs of energy and matter between landscape systems, being an excellent indicator of the alterations in the diverse systems where it pass through.

The contributor drainage basins at Jacarepaguá Lagoon are in a growing state of degradation due to an inadequate land use. A product of this inadequate land use is the alteration of the amount and quality of the sediments, which arrive at the lagoon transported by fluvial channels, and which changes directly lagoonal sedimentation rates and consequently its morphology. This paper analyses solid and liquid discharges and the satellite image interpretation of five catchments with purposes of diagnostic some disequilibriums caused by crescent urban occupation of this area without a good urban infrastructure.

URBAN DRAINAGE NET: MAN ACTION IN THE THIRD ORDER CHANNELS - PAQUEQUER RIVER, TERESÓPOLIS - RIO DE JANEIRO

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The present paper shows the change process in seven third order channels, tributaries of the Paquequer River, where is located Teresópolis city. The space perspective, considering punctual situations along the longitudinal profiles and the historical perspective, considering modifications along 41 years (1956-1996), were analysed.

For the spatial analysis, the alterations were evaluated in the geometry, considering the variables collected in the field: width, medium depth of the channel, medium depth of the channel in the water level, channel capacity, wet cross section area, wet perimeter, hydraulic radius, basin area, medium velocity of the flow and discharge. The channel balance was defined by the relationship between the channel capacity and the respective basin area.

For the temporal view, the growth of the impermeable areas was analysed, through aerial photographs, 1956 (1:33.000); topographical map of Teresópolis, 1966 (1:50.000); aerial photographs, 1976 (1:40.000); satellite image SPOT, 1996 (1:50.000). The channel beds were reconstituted through aerial photographs, 1956 (1:33.000); municipal plans, 1971 (1:2.000) and aerial photographs, 1994 (1:8.000).

The seven third order channels showed narrowing in different points of the longitudinal profile, with consequent channel capacity decrease. Increase of the impermeable areas in the basin was verified due to the urban growth, during 41 years. In 1996, the percentage of impermeable area ranged from 11,81% (basin of Paquequer Pequeno) to 53,80% (basin of Meudon), with consequences to the drainage net, such as covering of the rivers by galleries, alignment of buildings, bridges and houses.

GEOMORPHOLOGICAL ASPECTS OF THE HYDROGRAPHIC BASIN OF THE RIVER TAPAGEM - RONDONIA

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This paper is based on Scandolara (1990), RADAMBRASIL Project (1978), Nascimento et al (1977), Christofolletti (1980), Soares and Fiori (1976) and Cunha (1995) and analyses the geomorphologic aspects of the Tapagem River, Rondonia.

The identification of the morphological compartments of the basin was based on cartographic material and photo-interpretation using 30 monochromatic aerial photographs (1964) at the approximate scale of 1:70,000 (CPRM-REPO). The information was controlled with fieldwork.

Geomorphological map of the Hydrographic Basin of Igarapé Tapagem, in the district of Candeias do Jamari (RO), between the latitudes 8°55'S and 9°21'S and longitudes 63°30' W and 63°40' W, in which the area is approximately 774,05 square kilometres. It is a system of sixth order, presenting three compartments with diversified characteristics in relation to the slope angle and drainage density. The main topics are identified as well as sources and types of valleys and other phenomena known regionally as "águas emendadas", "parana-mirins" and by field control, waterfalls, "terras caídas", lakes, "furos", island and fluvial lands, which ended up in the referred river. We conclude that the compartments I and III are more similar, while the II is peculiar because it is more fully accidental, needing special care in the planning of its occupation.

Abstracts **delivered at IAG 1999 Regional Conference on** **Geomorphology**

SESSION: Tectonics and Landscape Evolution

1. THE OROGRAPHY OF THE NORTHEASTERN BRAZIL AND THE CRUST-MANTLE INTERFACE RELIEF: THE CORRELATION BETWEEN GEOMORPHOLOGIC AND GRAVIMETRIC DATA
2. MORPHOTECTONIC COMPARTMENTS ALONG THE AMAZON RIVER
3. TOPOGRAPHIC, GEOMORPHOLOGICAL AND GEOLOGICAL FORMS ON THE DOMES PLATEAU OF ARCOS AND THEIR RELATIONS TO THE RECENT TECTONIC
4. TECTONICS AND PALEOGEOGRAPHY ALONG THE AMAZON RIVER
5. QUANTITATIVE GEOMORPHOLOGY TO DEFINE MORPHOTECTONIC SETTING: THE CASE OF EASTERN ABRUZZO (CENTRAL ITALY).
6. TECTONIC CONTROLS ON MORPHOGENESIS AROUND SÃO CARLOS, RIO CLARO AND PIRACICABA, SÃO PAULO STATE (BRAZIL)
7. MORPHOTECTONIC FEATURES ASSOCIATED WITH MESOZOIC-CENOZOIC REACTIVATION OF THE RIO BONITO FAULT (SP/RJ)
8. MORPHOSTRUCTURAL COMPARTMENTS OF UPPER SAPUCAÍ VALLEY, POUSO ALEGRE REGION, MINAS GERAIS
9. ABRUPT FLUVIAL MIGRATIONS AND LAKE SYSTEM DEVELOPMENT AS CONTROLLED BY QUATERNARY TECTONIC EVOLUTION (MIDDLE VALLEY OF THE DOCE RIVER, SOUTHEASTERN BRAZIL)
10. NEOTECTONIC INFLUENCE ON RIVER CAPTURE SYSTEMS IN THE PARAÍBA DO SUL RIVER MIDDLE VALLEY (SOUTHEASTERN BRAZIL)
11. CENOZOIC TECTONIC CONTROLS ON RELIEF COMPARTMENTS IN THE MIDDLE VALLEY OF THE DOCE RIVER (SOUTHEASTERN BRAZIL)
12. LANDFORM MOSAIC RESULTING FROM THE CRETACEOUS AND CENOZOIC TECTONIC EVOLUTION OF SOUTHEASTERN BRAZIL
13. MORPHOTECTONICS OF AN INTERNAL REGION OF PASSIVE MARGIN: THE MINAS GERAIS STATE (SOUTHEASTERN BRAZIL)
14. RECURRENT TECTONICS AND KARST GENESIS IN THE UPPER SÃO FRANCISCO RIVER BASIN, SOUTHEASTERN BRAZIL
15. NEOTECTONIC CONTROL ON DRAINAGE NETWORK EVOLUTION IN THE AIURUOCA REGION, SOUTHERN MINAS GERAIS

16. RELIEF COMPARTMENTS IN THE MIDDLE VALLEY OF THE PARAÍBA DO SUL RIVER AND NEIGHBOURING MOUNTAINOUS AREAS (SOUTHEASTERN BRAZILIAN PLATEAU) - MORPHOTECTONIC RELATIONSHIPS

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THE OROGRAPHY OF THE NORTHEASTERN BRAZIL AND THE CRUST-MANTLE INTERFACE RELIEF: THE CORRELATION BETWEEN GEOMORPHOLOGIC AND GRAVIMETRIC DATA

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The Borborema, Ibiapaba and Araripe plateaus are extensive tracts of elevated lands (up to 950 meters high) in the interior of the Northeastern Brazil, which have undergone epeirogenetic movements during the Cenozoic. The entire region was previously deformed during the opening of the South Atlantic, in Cretaceous times, leaving behind important tectonic scars.

Outstanding topographic features were developed by the Cenozoic regional epeirogeny. Among them, there is a major, roughly elliptical alignment of ranges around the Potiguar Basin, defining a large amphitheater surrounding the onshore portion of the basin. This morphologic structure has a NE-trending symmetry axis which follows the Cretaceous rift, being responsible for the capture of many rivers which flow to the north.

Isostatic modelling based on gravimetric data suggests a 30 km thick crust beneath the elevated areas and at least 2 km of crustal thinning beneath the most topographically depressed regions.

The correlation between the major geomorphologic features and the variations in the crustal-mantle interface relief suggests that the present orography of this northern domain of the Northeastern Brazil reflects the crustal response to the Early Cretaceous extensional deformation.

MORPHOTECTONIC COMPARTMENTS ALONG THE AMAZON RIVER

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This work constitutes an example of intraplate application of the modern concept of Structural Geomorphology, which characterizes landforms and drainage patterns within the framework of the neotectonics of the Amazon region. The neotectonics conception adopted here comprises the various structural systems, the sedimentary sequences, the land systems and the pattern and anomalies of drainage which were developed during the late Tertiary and Quaternary.

Controversy is particularly intensive over the channel of the Amazon river, between the cities of Manaus and Belém, where plains are found in uplifted areas and also a large diversity of drainage patterns and anomalies. The main goal of our work is to establish a correlation between the complex geomorphological patterns and the structures derived from the transcurrent movements of the Miocene-Pliocene and late Pleistocene-Holocene. This implies in a revision of the concepts based on morphoclimatic conditions or in the domain of vertical movements.

The scale of the geomorphological problems dictated the methodology, on a regional basis, which led to the characterization of six morphotectonic compartments as follows: Manaus-Nhamundá, Tupinambarana, Baixo-Tapajós, Comandá, Gurupá e Marajoara.

The development of these compartments is not directly related to the evolution of the northern and western borders of the South-American plate.

TOPOGRAPHIC, GEOMORPHOLOGICAL AND GEOLOGICAL FORMS ON THE DOMES PLATEAU OF ARCOS AND THEIR RELATIONS TO THE RECENT TECTONIC

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In the state of Minas Gerais/Brazil, a plateau unit has been identified through geomorphological mapping, in the upper basin of the Sao Francisco river. This unit was developed over granite rocks of the Divinópolis Complex and clay rocks of the Bambuí Group. The occurrence of topographic variations, denudational processes with variable intensities, the characteristics of the drainage and dissection patterns, and depositional forms indicate the presence of tectonic activity during the Cenozoic. The neotectonic movements uplifted the Domes Plateau of Arcos and controlled the development of sculptural forms.

The topographic variations caused by the distribution of granite rocks between the heights of 720 and 1020m, which show a topographic unevenness of 300m in a stretch of approximately 7km on a map, reflect a tectonic dislocation due to the domes uplifting in a small stretch of land.

The presence of an annular-radial drainage pattern, associated with V-shaped, downcutting and high hydraulic gradient valleys, are signs of intense dissection processes related to uplifting.

Geomorphological forms which are sculptured on the granite dome, such as: dissection, terrace levels, intense headwater erosion by the fluvial channels, gullies, narrow-topped dissected watersheds, fluvial valleys in closed V-shaped, remains of planation surfaces associated with laterites levels forming rapids and local base levels controlling the formation of alluvial plains segments, indicate that the dome has undergone uplifting.

TECTONICS AND PALEOGEOGRAPHY ALONG THE AMAZON RIVER

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The main structural and geomorphological features along the Amazon river are closely associated with tectonic events throughout the Mesozoic and Cenozoic.

The Mesozoic tectonic setting is characterized by two distinct extensional segments (Amazon and Marajó basins). The Amazon basin is formed by NNE-SSW normal faults, which control the emplacement of dolerite dykes and the deposition of the sedimentary pile. During the next subsidence phase, under low rate extension, probably in the early Tertiary, much of the drainage systems reversed, directing the paleo-Amazon river to flow towards the east. The Marajó basin encompasses NW-SE normal faults and NE-SW transcurrent faults. The normal faults controlled the deposition of thick rift and post-rift sequences, and the emplacement of dolerite dykes. The Arari Lineament, which marks the northwestern boundary of the Marajó basin, has been working as a linkage corridor between the paleo and modern Amazon river and the Atlantic Ocean.

The neotectonic, from Miocene, comprises two sets of structural and geomorphological features. One set (Miocene-Pliocene) encompasses two transpressive trending NE-SW domains and one transtensive trending NW-SE domain, which are linked to E-W and NE-SW right-hand strike-slip systems. The second set (Pliocene-Holocene) refers to two triple junctions of R-R-T and T-T-R types, and two large transtensive segments, which have controlled the orientation of the modern drainage patterns.

QUANTITATIVE GEOMORPHOLOGY TO DEFINE MORPHOTECTONIC SETTING: THE CASE OF EASTERN ABRUZZO (CENTRAL ITALY).

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The relations between structural setting and morphological arrangement have been examined by means of morphotectonic analyses in a study area of Central Italy, located between the Apennine Chain and the Adriatic Sea, and corresponding to part of the Adriatic foredeep.

Previous morphotectonic researches performed on this area at the University of Rome "La Sapienza" made it possible to identify three sectors which differ for their morphological and neotectonic style.

Starting from these results further investigations were carried out with the aim of highlighting the different features of each sector and of defining more precisely the sector boundaries. This study utilized landform analyses that focus on the response of drainage patterns to topographic variations created by structural arrangement in general and active tectonics in particular. Several morphotectonic parameters have been calculated, such as amplitude of relief, asymmetry factor and transverse topographic symmetry factor. Their values showed areal variation in relation with the different sectors experiencing tilting and differential uplift. Moreover, the statistical analysis of stream directions evidenced that drainage network preferential orientations - and of the first order channels in particular - show a rotation moving from North to South, which suggested the possibility that the boundary between the northern and the central sector is represented by a right-lateral strike slip fault.

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TECTONIC CONTROLS ON MORPHOGENESIS AROUND SÃO CARLOS, RIO CLARO AND PIRACICABA, SÃO PAULO STATE (BRAZIL)

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This work presents results related to morphogenesis, recent sedimentary deposits and their tectonic control in the region of São Carlos, Rio Claro and Piracicaba, São Paulo State (Brazil). The investigation is based on geological and geomorphological maps with emphasis in the drainage pattern and its anomalies, and also major lineaments and terrain digital modelling. The main recognized structural features are joint systems with directions NW-SE, NE-SW, N-S and E-W, with associated normal and or transcurrent faults. Cenozoic deposits lie over four distinct geomorphologic levels since the tops until the alluvium plains. They are distributed in a discontinuous arrangement forming structural or lithologic steps controlled by the major lineaments. Those deposits are composed by basal conglomerate and upper sandy-argilaceous units, associated with debris flow and locally aqueous flow. Drainage net, relief sculpture and Cenozoic sedimentary covers distribution show strong controls along lineaments, associated with tilting or collapse of blocks, promoting channel lateral migration, abandoned meanders, drainage captures and asymmetric valleys, triangular or trapezoidal facets and related dejection fans. This association points to neotectonic activity, related to the drift and rotation of the South American Plate towards west.

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MORPHOTECTONIC FEATURES ASSOCIATED WITH MESOZOIC-CENOZOIC REACTIVATION OF THE RIO BONITO FAULT (SP/RJ)

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The Rio Bonito fault belongs to the group of Precambrian shear zones with direction NE-SW, reactivated by the extensional tectonic event associated with rupture of the Gondwana continent, which structures are responsible for the evolution of the Brazilian south-southeastern landforms. This fault is a bend of the Taxaquara fault developed near to Campos da Cunha (RJ) that, following the strike NE, crosses adjacent to the São José do Barreiro (SP), up to Volta Redonda (RJ), limiting the homonymous basin at northwest. Geomorphologic elements, configuring morphotectonic features, observed along the fault, exhibit indications that the reactivation is still in course, associated with the compressive couple NW-SE. The main features of reactivation are slickensides, asymmetries of the Barreiro de Baixo river valley that fit along to this fault, drainage anomalies and specific landforms. Outstanding features can be observed like lateral stream migrations associated with tilting of blocks to NW and SE, knick points, meander scars belts that eventually becomes to oxbows lakes, belts of well defined meanders, ruptures of terraces, drainage captures creating elbows and wind gaps, deflection and offsets drainage along the line of strike slip fault NE-SW and E-W. The morphotectonic features are identified by aligned suspended hollows, shutter ridges, gullies and triangular facets with evolution associated with the Holocene erosion of the fault scarp. The erosion was responsible for a large deposition of alluvium-colluvium sediments along both valleys and hollows. Active compressible stress are suggested by the abrupt vertical incision of the drainage in the floodplain of Barreiro de Baixo river, terraces and, eventually, in Holocene colluvium fans. This tectonics promotes warping in the area, as well as the rearrangement of alternate blocks, as observed in the Brazilian Platform.

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MORPHOSTRUCTURAL COMPARTMENTS OF UPPER SAPUCAÍ VALLEY, POUSO ALEGRE REGION, MINAS GERAIS

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Geomorphologic studies in the Pouso Alegre (MG) region show four morphologic units related to tectonics lineaments revealing ancient structures (E-W and ENE-WSW).

Unit I - RANGE OF CERVO - it has trends of strike-slip faults related to Espírito Santo do Dourado (E-W) and Senador José Bento faults, with the drainage associated with these directions. Mounts, Mountains and low Mounts landform types are associated with this unit, showing aligned hanging valleys, steps in the river longitudinal profile and drainage captures.

Unit II - ELONGATED LANDFORMS SHARED BY CERVO, MANDU AND TURVO RIVER VALLEYS - limited at North by Jacutinga fault (E-W) and at South by Monte Siao fault (ENE-WSW). The Jacutinga fault produces negative breaks of slope along the Cervo River valley extension, with steps of scarps, showing surfaces inclined to NW. In those surfaces it is identified a meander scars belt associated with the tilting and with the Cervo River migration.

Unit III - LOW HILLS - limited at North by Monte Siao fault (ENE-WSW) and at Southeast by Camanducaia fault (NE-SW) it has a lowered convex hill relief and, on the other hand, no slope breaks associated with the thick colluvial material.

Unit IV - MOUNTS AND MOUNTAINS - it is characterized by an high block elongated in the NE-SW direction, limited at North by Monte Siao fault (ENE-WSW) and at Southeast by Senador Amaral fault (NE-SW). Along the last direction are associated spurs of the more important scarps, characterized by great valleys with an evident erosion (dissection) with discontinuous deposits and thin material. Triangular facets, hanging valleys filled by colluvium-alluvium material, dry valleys, valley asymmetry are associated with these characteristics revealing recent tectonic activities.

ABRUPT FLUVIAL MIGRATIONS AND LAKE SYSTEM DEVELOPMENT AS CONTROLLED BY QUATERNARY TECTONIC EVOLUTION (MIDDLE VALLEY OF THE DOCE RIVER, SOUTHEASTERN BRAZIL)

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Remarkable geomorphologic and sedimentologic features observed in the middle valley of the Doce river (Minas Gerais State, Southeastern Brazil) have supported discussions concerning to paleoclimatic and neotectonic controls on the Cenozoic evolution. The most impressive feature is represented by a Quaternary barred lake system. Many authors have related the origin of the lakes to the damming of the mouth of tributary valleys by an intensive sedimentation at main channels. Another important feature corresponds to distinctive paleochannel traces developed on large infilled valleys which are parallel to the present course of the Doce river. These paleovalleys are bordered by lakes. This work presents new evidences of neotectonic controls on the development of these geomorphologic features. Detailed geomorphologic and structural analysis support neotectonic interpretations. Seismic stratigraphic survey of the main lacustrine body in the lake system (Dom Helvécio Lake) was carried out and has revealed meaningful submerged features. It is proposed that the beginning of the lacustrine evolution was influenced by an early Holocene E-W dextral transcurrent tectonic stage that strongly affects Pleistocene deposits. It would have obstructed the flowoff of the tributary drainages and promoted the filling up of the main fluvial valleys by a relatively thick Holocene alluvial sequence. The paleochannel traces are developed on this alluvial sequence and so they are younger than this deposition. The abandonment of the infilled valleys is directly related to the lake damming and both are controlled by neotectonic mechanisms. They are related to an abrupt migration of the Doce river channel that is controlled by an Holocene NW-SE extensional tectonic stage. Seismic profiles at the mouth of the Dom Helvécio Lake document a remarkable NE-SW normal fault related to this neotectonic stage. This extensional phase was responsible for the isolation of the lakes from the fluvial system leaving lacustrine bodies aligned in NE-SW direction, parallel to the paleochannel directions.

*Supported by FAPESP, CAPES and CEPG-UFRJ.

NEOTECTONIC INFLUENCE ON RIVER CAPTURE SYSTEMS IN THE PARAÍBA DO SUL RIVER MIDDLE VALLEY (SOUTHEASTERN BRAZIL)

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This work aims to analyze the influence of neotectonic mechanisms on the development of distinctive river capture patterns in the Paraíba do Sul river middle valley. This area is inserted in the Continental Rift of Southeastern Brazil (CRSB), that corresponds to a block-faulted morphology originated by a NW-SE extensional tectonic regime during Eocene/Oligocene times. The resulting morphology is characterized by mountainous escarpments alternate to Cenozoic sedimentary basins. The area is dominantly constituted of Precambrian crystalline rocks (biotite gneisses and migmatites) with a well-marked NE-SW orientation related to metamorphic foliation, ductile shear zones and transcurrent faults. The regional landscape evolution is more influenced by Cenozoic tectonic events than lithologic variations. By detailed analysis of the regional drainage network, three river capture systems could be distinguished. Allostratigraphic analysis of the Cenozoic deposits and structural analysis of the joints and faults affecting them support the interpretations about neotectonic controls and its chronologic ordenation. An older river capture system is marked by abrupt inflections of the major fluvial courses mainly to NW direction. The most impressive example of this system is the Barreiro de Baixo river inflection. The supposed paleovalley preserves a thick succession of Tertiary sediments. This capture system is tentatively related to a NW-SE extensional stress caused by a Neogene (Pliocene?) sinistral E-W transcurrence. Another capture system is characterized by SW and NE orientations and affects a large number of low-hierarchy drainages and the traces of main fluvial courses. It seems to be controlled by NW-SE structures and leaves Pleistocene deposits at the divide position. The structural control and morpho-allostratigraphic relationships led to relate this capture system to a Pleistocene/Holocene E-W dextral transcurrence. It is better distinguished on the northern border of Resende basin. A more recent capture system is characterized by orientations mainly to SE and less prominent to NW and by the occurrence of Holocene alluvial deposits at divide positions. The divide of Barreiro de Baixo and Piracema rivers is the best example of this system, that is caused by NE-SW normal faulting related to an Holocene NW-SE extensional event.

CENOZOIC TECTONIC CONTROLS ON RELIEF COMPARTMENTS IN THE MIDDLE VALLEY OF THE DOCE RIVER (SOUTHEASTERN BRAZIL)

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The middle valley of the Doce river is situated at the central to eastern portion of the Minas Gerais State (SE Brazil) and corresponds to a depressed area associated with a tectonically-controlled evolution during Cenozoic times. In this area, it was carried out a regional geomorphologic investigation based on the analysis of the altimetric variations and on the fluvial dissection degree. Detailed structural analysis of the joints and faults affecting Cenozoic sediments support the interpretation of the neotectonic controls on relief compartmentalization. Three major geomorphologic compartments could be distinguished, as following: a) Doce River Middle Valley (MVRD) Depression, that is characterized as an hilly domain with altimetric ranges between 200 and 500 meters and low fluvial dissection (from 50 to 200 meters of altimetric difference associated with fluvial dissection); b) High Topographic Domain at the Eastern Side of the MVRD Depression, characterized by altimetric ranges between 500 and more than 1,100 meters and medium to high fluvial dissection (from 200 to 400 meters); and c) High Topographic Domain at the Western Side of the MVRD Depression, characterized by altimetric ranges between 500 and 1,100 meters and high fluvial dissection (from 200 to more than 400 meters). This main relief compartmentalization can be related to a first Cenozoic tectonic phase (Neogene E-W sinistral transcurrent). The NW-SE distensive stress associated with this tectonic event results on the main NNE-SSW orientation of the major high and low topographic blocks which represent a block-faulted morphology. Remarkable NW-SE to E-W segmentation of the major compartments is controlled by tectonic structures associated with a second Cenozoic tectonic phase (Pleistocene to early Holocene E-W dextral transcurrent). This tectonic event has greatly influenced on the development of a regional lacustrine system and on the retention of a relatively thick Holocene depositional package. The final damming of the lacustrine bodies has been documented as controlled by a third Cenozoic tectonic event, that is characterized as an Holocene NW-SE extensional phase.

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LANDFORM MOSAIC RESULTING FROM THE CRETACEOUS AND CENOZOIC TECTONIC EVOLUTION OF SOUTHEASTERN BRAZIL

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The NE trending structural framework of the crystalline rocks that occur between the Coastal Plain, the Mar and Mantiqueira mountain ranges and the Paraíba do Sul river valley is inherited from the Neoproterozoic to Ordovician Western Gondwana assembly, during the Brasiliano Orogeny. At Cretaceous, huge NW trending hog-back morphology had modified the landform. It represents the continuation to the continent of structural highs that separate marginal basins of the same age at the South Atlantic passive margin. The Cabo Frio High separates Santos and Campos marginal basins since late Cretaceous and can be identified in the continent by drainage basin organization in the Paraíba do Sul valley. Hydrologic convergence areas had evolved at the base of steep scarps near Tres Rios, Volta Redonda-Resende, Taubaté regions, respective to Cabo Frio, Rio de Janeiro and Queluz highs. Similar features occur at the Coastal Plain, associated with the Guanabara and Sepetiba bays. The Tertiary tectonics rearranged the drainage network, increasing the topographic gradient and the erosional-depositional activities. Sedimentary deposits have filled the resulting basins (Taubaté, Resende, Volta Redonda and Guanabara). The Barra Mansa transfer zone displaced the rifting axis to SE, close to the coast, in a way that no sediment deposits have formed at Tres Rios area, probably due to a less effective Tertiary tectonics. The Paraíba do Sul Delta is a late Cenozoic feature, which indicates that the present drainage basin is a consequence of a capture along a Neoproterozoic vertical shear zone during Neogene times. Therefore, at Southeastern Brazil we can observe relict Cretaceous and reworked Cenozoic land surfaces. In this way, the Paraíba do Sul valley landscape may be considered as a mosaic of landforms with different slope evolution along the geological time.

MORPHOTECTONICS OF AN INTERNAL REGION OF PASSIVE MARGIN: THE MINAS GERAIS STATE (SOUTHEASTERN BRAZIL)

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The São Francisco Craton (CSF) is the main geological unit of Minas Gerais State. Morphologically, the CSF constitutes a huge N-S depression, the São Francisco River valley, bordered by two tilted plateau, the Planalto do Espinhaço at east and the Planalto do Alto Paranaíba at west. These highlands resulted from Neogene uplift of the folded belts frontal parts that deformed the CSF margins during the Upper Proterozoic. This uplift took place after the Late Cretaceous-Paleocene planation (Sul-americana Surface, King 1956) responsible for the stronger flattening of the Brazilian Platform. Resulting from the same evolution, the two southeastern coastal ranges (Serra do Mar and Serra da Mantiqueira) correspond to uplifted blocks confining the Paraíba do Sul Rift valley (Almeida 1976), which was filled by Paleogene continental sediments with a couple of 100 meters thick. Along the CSF southern margin, the end of this morphotectonic event is recorded by the formation of São João del Rei Rift Zone-SJRRZ (Saadi 1991), which exhibits fluvio-lacustrine sediments with more than 120 meters thick. Analysis of pollens extracted from lignite indicates an Oligocene-early Miocene age (R. Maizato - UFOP, 1998), similar to the sediments of Tertiary basins on the east part of Quadrilátero Ferrífero (Gorceix 1889). The main part of these morphotectonic features results from a morphogenesis under hot-humid climate and compressive tectonics characterized by Saadi (1991) for the Minas Gerais State and Costa et al. (1998) for its southern portion. Basseto & Szatmari (1997) describe compressive structures into the ocean crust of the southeastern Brazilian margin compatible with the continental evolution presented here. Their sedimentary data indicates the development of this structure since the Oligocene until today.

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RECURRENT TECTONICS AND KARST GENESIS IN THE UPPER SÃO FRANCISCO RIVER BASIN, SOUTHEASTERN BRAZIL

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The Arcos-Pains-Doresópolis Karstic Province is located along the southwestern border of the São Francisco Craton-CSF, which is drained by tributaries of the upper São Francisco river valley. The karst is developed on limestones and dolomites of Bambuí Group (Upper Proterozoic). This stratigraphical unit also includes phyllites and is installed over Archean granites and gneisses. The Precambrian deformation includes thrust and strike-slip faults, as well as folds affecting the rocks of Bambuí Group in some areas.

Morphologically, it is a typical humid tropical karst characterized by towers and a great variety of dolines, formed in many different ways (collapse, solution and subsidence) and situated on plateaus and hilly compartments. More than 60 mapped caverns are organized into three altitudinal subterranean levels corresponding to stages of baselevel lowering, which constituted the responses of the São Francisco river entrenchment to the Cenozoic uplift pulses. This evolution is analyzed in basis of the terrace system installed at borders of a 100 meters high karstic canyon.

Morphotectonic studies involving interpretation of aerial photographs, geomorphological mapping and field survey of neotectonic structures, including statistical analysis of its relations with karstic features (dolines and caves) show:

- the area was updomed several times resulting from NW-SE to W-E compressive stress field;
- the main axis of updoming, oriented N-S, constitutes an inheritance of the Upper Proterozoic compressive deformation which Cenozoic reactivation has controlled the formation of several old caverns;
- the canyon was formed by down-cutting process into limestones and phyllites;
- two N35-40W oriented depressions correspond to Upper Cenozoic grabens generated by the reactivation of a N50W oriented strike-slip shear zone (Crustal Discontinuity of Upper São Francisco River-DCARSF, Saadi 1991);
- the formation of more recent dolines and caves is predominantly controlled by the neotectonic N35-40W normal faults.

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NEOTECTONIC CONTROL ON DRAINAGE NETWORK EVOLUTION IN THE AIURUOCA REGION, SOUTHERN MINAS GERAIS

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The Aiuruoca region involves part of Mantiqueira Range (from 1.800 to 2.350 m high) and Alto Rio Grande Plateau (from 900 to 2.000 m high) presenting a complex morphotectonic framework which resulted from two tectonic events (Paleogene and Neogene-Quaternary). The events were recognized by faults mapping and control on drainage rearrangement and distribution and deformation of superficial deposits. The first one, extensional, is related to the Atlantic opening processes, and the second one, transcurrent, to intraplate neotectonics.

The Cenozoic tectonic activity modified the landscape by rearrangements of drainage and relief forms, preferentially along the dextral ENE-WSW and E-W transcurrent zones originated or reactivated during the rifting in Late Cretaceous-Early Tertiary.

The progressive advance of fragmentation towards the hinterland in the Paleogene implicated truncation, tilting and subsidence of ENE blocks, and progressive migration of regional divide to this direction causing partial capture of the upper interior hydrographic basins by headward retreat that inverted their flow.

Since Late Tertiary, the area has been submitted to transcurrent tectonics with transpressional component and reactivation of earlier structures, with differential uplift of ENE blocks and increasing tilting towards NNW, inverting the tendency of divide migration. This process has provided the rearrangement of the upper basins of the Grande, Preto and Ingaí rivers by capture, diversion and beheading processes indicated by asymmetry and morphological and geological features, with growth of the Aiuruoca basin. Two captures were dated by C¹⁴ of organic horizons and paleosoils with 30.070 ± 370 and 7.300 ± 80 y. B.P., and the palaeoenvironment was reconstituted by palynologic analysis.

This activity persists nowadays as indicated by imminent drainage rearrangement processes.

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RELIEF COMPARTMENTS IN THE MIDDLE VALLEY OF THE PARAÍBA DO SUL RIVER AND NEIGHBOURING MOUNTAINOUS AREAS (SOUTHEASTERN BRAZILIAN PLATEAU) - MORPHOTECTONIC RELATIONSHIPS

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A map of relief compartments based on the fluvial dissection degree analysis was elaborated for the region of the Paraíba do Sul river middle valley and neighbouring mountainous areas. The studied area includes the coastal mountain ranges of "Serra do Mar" and "Serra da Mantiqueira" as well as the adjacent hinterland hilly areas, in the limits of São Paulo, Rio de Janeiro and Minas Gerais states. The geologic setting is characterized by Precambrian crystalline basement transected by transcurrent faults and shear zones with NE-SW orientation. During the Meso-Cenozoic an important tectonic reactivation occurred and was responsible for the formation of remarkable geological features: the uplifting of the "Serra do Mar" and "Serra da Mantiqueira" and installation, between them, of the Continental Rift of the Southeastern Brazil (CRSB), with ENE direction, where the Paraíba do Sul river is installed. The three major relief domains are stood out in the produced map, where some conspicuous aspects, not emphasized in previous studies, can be observed, as the E-W orientation of the major compartment limits. The relief compartments are mostly controlled by NE-SW, NW-SE and E-W structures. Their spatial arrangement reproduce a rhomboidal structural pattern that is related to the Cenozoic tectonic evolution of the Southeastern Brazil, where the rhomboidal features are limited in the eastern and western sides by NE-SW lineaments associated with the reactivation of Precambrian structures, and in the northern and southern sides by transference zones with E-W orientation, formed during the Atlantic Ocean opening and reactivated during the drift phase.

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Abstracts **delivered at IAG 1999 Regional Conference on** **Geomorphology**

SESSION: Coastal Geomorphology

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SHOREFACE SEDIMENT DISTRIBUTION AND ASSOCIATED BEACH MORPHODYNAMIC STATE OF THE RIO DAS OSTRAS - CAPE BÚZIOS EMBAYMENT (RIO DE JANEIRO-BRAZIL)

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Beach and shoreface grain size as also topography and morphodynamic state along part of the beach arc in the Rio das Ostras-cape Búzios embayment are strongly dominated by the deposition of fine sediments provenient from the Sao Joao river. Sandy sediments dominate the northern upper shoreface while the southern upper shoreface is covered by muddy sediments. Relict coarse to very coarse sands occurs at the middle to lower shoreface. Influence of river sediments become increasingly significant to beach and shoreface morphology from the middle of the beach arc in direction to the south. Northward of the Sao Joao river mouth the beach is coarse grained with a steep beach face, narrow beach berm and almost absence of a surf zone. Upper shoreface is also coarse grained and steep. Southward of the river mouth, in the direction of net suspended sediment transport, the beach becomes increasingly finer grained and the topographic profile gradually flattened as also the shoreface, with the beach stage changing to dissipative.

MONITORING OF EROSION OF IPANEMA AND ARPOADOR BEACHES , RIO DE JANEIRO, RJ, BRAZIL

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The actual erosive phase of the east part of the beaches of Rio de Janeiro State has started during the year of 1997 and, became extreme after March of 1999.

Photographic documentation has been realized from 1997 and compared with pictures and satellite images took before.

The natural anomalies in sedimentary transport cycle and in the sea level are yielding the intense erosion on the littoral of Rio de Janeiro City and others, in the southeast coast of Brazil, classified as an environmental impact. There is erosion beyond the foundations of life-guard spot houses N. 8 at Ipanema beach and N. 13 at S. Conrado beach, where the seawall protections and the walkways breakdown. In these beaches, the berm sands get out, the sea acts directly on the seawall and at Arpoador beach occurred a rupture connected with the destruction of the last ramp access to this beach, where escape the soil material and the walkway gone under. In Ipanema beach, a layer of gross material of artificial embankment, the tubes of submarine sewage outfall and dangerous steel planks have been exposed. The quality of these beaches, as resort, deteriorated.

During the year 1997, erosive phases seemed to have been caused by natural anomalies on the alongshore transport, that are added to the intense erosive phase started in the middle of March of 1999. This erosion, specially strong between 18 and 19 of April of 1999, was caused mainly by the high waves associated with the rising of sea level, basically a storm surge. This surge has commonly components of wave set-up, wind set-up and the rise of sea level as a result of an atmospheric cyclone low pressure area, that moves against the coast, surrounded by high pressure areas offshore, that yields a hump in the sea surface. The coincidence with a phase of high water spring level occurred.

Other possible component of erosion cause must be the out of phase of the normal storm season in relation with the monthly sea level distribution along the year. The normal storm's season is mainly during July and August, the minimum monthly normal sea level is during August to September and the peak of maximum monthly normal sea level is during May in the southeast Brazilian coast. The time lag is probably connected with large-scale phenomena like El Nino in 1997 and La Nina in 1999, when strongest annual storms occurred in the end of May.

The history of the city remembers us, in the past recent, some inclination of buildings on the coast, function of static and dynamic pressures in the soil, due respectively to the rise of sea level and to the waves, that communicate indirectly its hydraulic loads through the beach ridge, where the buildings lie.

GEOMORPHOLOGIC EVOLUTION OF THE LONG ISLAND - COAST OF SAO PAULO/BRASIL

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Understand the dynamics that governs the physical attributes of the environment is indispensable in every planning work and environmental management. This understanding assumes larger importance in coastal areas face the speed of the action of agents that there act. This process materializes in the relief transformations along the time. For this work, the Long Island was defined, with 74 Km of coast line, as study area. Located in the coast south of the State of São Paulo, this barrier island was formed by marine sands, linked to events glacio-iso-eustatic, and is component of an important Coastal Complex, denominated "Complexo Estuarino-Lagunar de Iguape/Cananéia". For the study of the geomorphologic evolution of this Island, maps was made en three different sceneries - 1962, 1974 and 1991, being used for this of stereoscopes equals of aerial photographies in the scale 1:25,000. Later on the three maps were transposed for the scale 1:50.000, allowing a good visualization of the material. Thus, starting from the comparison and overlap of the same ones, it can be proven the great morphologic variation presented by the Ilha Comprida, associated to the processes of erosion and deposition. The main verification is the increment, in area, in its northeast extremity, caused by the contribution of sands. The erosive processes is linked to the progress of the coast line in detriment of the Iguape Island. In the interior margin of the Ilha Comprida the constant joining of "islands" and sandy banks have been the main geomorphologic modification found.

GEOMORPHOLOGIC CHANGES IN THE ITAIPU LAGOON (NITERÓI / RJ) RESULTING FROM ANTHROPOGENIC ACTIVITY

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The Itaipu Lagoon, located in Niterói, Rio de Janeiro State, was deeply affected by urbanization during the 70's and 80's, causing major geomorphologic changes. Dredging of the lagoon bottom and reopening of the tidal inlet in 1979 caused lowering of water level with consequent reduction of the wet area. Comparison of aerial photographs taken in 1976 and 1996 quantified in 33.9% the reduction in water surface. Bathymetric survey indicated that 80% of the lagoon bottom is flat and very shallow (around 1 meter deep). The shallow areas are covered with mud derived from the drainage, which is accumulating at a rate of 0,28 cm/year for the last 100 years, based on 210Pb analyses. Deforestation and human occupation of drainage and lagoon margins accelerated the shallowing up of the lagoon. Other morphologic features are a 6-meter deep dredged channel and a flood tidal delta. Sands coming from the beach and nearshore zones through the tidal inlet are concentrated by present-day lagoon hydrodynamics along the deep channel and on the tidal delta, where sand is moderately sorted. Tides generate a clockwise circulation within the lagoon with current velocities between 0.02 to 0.3 m/s and up to 2.47m/s in the inlet. Tidal currents and sporadic storm waves are responsible for transport, removal and distribution of the sands on the lagoon bottom.

GEOMORPHOLOGIC CRITERIA FOR THE MORPHODYNAMIC ZONING OF CANTABRIAN COAST ESTUARIES

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The Cantabrian Coast (N. of the Iberian Peninsula) is characterised by its erosive nature and its high cliffs sectioned by narrow and inland-extended estuaries, which are several hundred metres width and less than 15 km long. The origin of these estuaries can be traced back to a series of river beds engagements on the raised coast as well as to further fillings related to sea level eustatic variations during the general Holocene transgression.

Although there is a general tendency in the Cantabrian coast estuaries to repository backfilling, human activity has contributed to speed up this process by the construction of some elements which avoid or refrain sea waters access. Consequently, its elements reduce the tide lands floor in favour of land used for agricultural and stockbreeding purposes. This phenomenon has been especially intense throughout the 20th Century and has caused an impact on the estuarine natural environment. The analysis and recovery of this impact requires knowing the extent of the tidal dynamics and the accurate demarcation, from a dynamic viewpoint, of the estuaries zones as well as their anthropic alteration.

The zoning of two important estuaries in the central sector of the Cantabrian Coast, the Ribadesella and the Tinamayor ones, highlights the difficulties in approaching this type of study and shows the most valid geomorphologic criteria for zoning. The detailed geomorphologic cartography and the range of the tidal wave during the present spring high tides, shows that the tideways extension, their typology and the existence of scarps between areas located at different heights in the estuarine deposit and the alluvial plain allow us to identify three units: low, middle and high terraces. These units have shown an ever decreasing tidal influence. The supplementary analysis of aerial photographs from the last 40 years contributes to clarify the mentioned zoning and to characterise some recent anthropic impacts.

DETERMINATION OF THE BEACH MORPHODYNAMIC STATE: A NEW APPROACH WITH BETTER RESULTS?

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Determination of the beach morphodynamic state using Dean's Δ parameter frequently results in wrong classification, mainly for the intermediate stages. This is a consequence of the low correlation between the settling velocity (or grain size) of the beach face sediments and the topographic gradient, when applied to a single beach. For this reason a new approach for the identification of the morphodynamic state is proposed by inferring a new parameter (Δ) obtained through the comparison of the wave height (H_{bs}) and mean wave period (T) in the outer breaker zone to the height and duration of wave uprush at the beach face as a surrogate measure of the wave energy dissipation in the surf zone using the equation:

where Δ is the beach face gradient, D_{up} the distance of wave run-up, T_{up} the mean duration of the significant wave run-up and T the mean wave period. The method was compared to the visual classification of four beaches, of distinct wave climate, grain size and morphodynamic state, located north and westward from Cabo Frio, using the results of twenty four monthly measurements of beach and surf zone profiles during low spring tide associated to measurements of wave height, period and sediment settling velocity. The result allowed a reasonably good discretization between the different states, with exception of the Rhythmic Bar and Beach State, which was not observed during the fieldwork. The following limits were found:

Beach State	Δ Parameter
Dissipative	<0.5
Longshore Bar and Trough	0.5-0.8
Transverse Bar and Rip	0.8-1.0
Low Tide Terrace	1.0-2.0
Reflective	>2.0

This result should be considered as a first approach, and only the application and test of the method in different places will give a more reliable answer of the applicability of this procedure.

A REVISION OF THE NAMES OF SUBMARINE FEATURES IN THE BRAZILIAN CONTINENTAL MARGIN AND ADJACENT AREAS

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The comparison of the denominations of submarine features in different cartographic documents frequently reveals the use of different names for the same feature or even the same denomination for different features. Furthermore topographic forms frequently show an inadequate geomorphic classification. In the course of the establishment of the Legal Brazilian Continental Shelf it was decided to revise the whole nomenclature of the undersea topographic features of the Brazilian continental margin.

The Working Group (members above) created in 1998 to review the undersea feature names based the discussions on previous maps elaborated by K. Jinno which show the denominations according to three sources: the "Projeto de Reconhecimento da Margem Continental Brasileira" (REMAC - Brazilian Continental Margin Reconnaissance Project)

$$\Delta = \frac{(\sin \beta \cdot D_{up})}{T_{up} \cdot T}$$

"Departamento Nacional da Produção Mineral" (DNPM - Brazilian geological survey), and the Naval Research Laboratory/Directorate of Hydrography and Navigation's South Atlantic Ocean Bathymetric Map.

As already pointed out, the Working Group faced two types of problems. One was the use of more than one location name for the same feature, as Recife Plateau and Pernambuco Plateau. In cases like this, of a large geomorphologic feature, the denomination of the State was preferred, instead of the name of the State capital.

These and other geographic denominations were reserved for smaller features like canyons. The second problem was the inadequate geomorphic classification of features. The most widespread was the use of the term bank, that is applied in the nautical sense, i. e. considering only the aspect of water depth. The Abrolhos and Royal Charlotte banks actually are shelves. Other examples of wrong denominations are the terms bank and seamount for some "guyots".

The result of the discussions will be submitted to the Sub-committee on Undersea Features Names of the General Bathymetric Chart of the Ocean (GEBCO) for approval.

EVOLVING TEMPORAL/SPATIAL CONCEPTS IN COASTAL GEOMORPHOLOGICAL RESEARCH

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The conduct of coastal geomorphological research in large part consists of the identifications of temporal and spatial variations in natural processes and the additional modification by cultural manipulation on the responses to these processes. Importantly, this approach supplants the common concept of a simple/single equilibrium developmental response with an approach which is directed toward a more flexible dynamic model. There are two major natural factors drive in the variable developmental response to the ambient processes in the coastal zone:

1. the temporal/spatial variation in sediment delivery and availability, and
2. the changing spatial position of the processes associated with a transgressing or regressing sea level.

In addition, the recent centuries have witnessed an increasing interruption and interference with both processes and sediment as humans intervene and modify the spatial/temporal associations.

Conceptually, aspects of the broadened scope of coastal geomorphological inquiry have been directed toward an increased understanding of the varying sediment supply and changing sea-level conditions at the coast and this has led to a bit more catastrophism in the evolving paradigm as it incorporates a multiple scalar approach to landscape evolution and includes an acceptance that natural conditions are variable and that human interaction with the natural system may lead to development of yet another assemblage of landform responses.

THE NATURAL SYSTEMS OF SANTA CATARINA COAST

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The landscape compartmentation and its structure and processes characterization is part of the Environmental Diagnosis of Santa Catarina Coast, a project developed by the IBGE Geoscience Administration together with the Coastal Management National Plan, specifically in what concerns to zoning.

The Santa Catarina coast reveals a broad and complex natural diversity along its 531 km of coast, 9,250 km² of surface and approximately 1,500,000 people among 34 cities.

The coast compartmentation is a result of many levels and stages of multiple synthesis and interdisciplinary formulas based on a methodology founded on the System General Theory and on the division of the landscape as a model established by Bertrand.

The adopted methodology established three taxonomic levels hierarchically organized, where the morphostructure domains create the larger taxon, followed by their geosystems which are divided into geofacies. These constitute the smaller units in which many studies were done both in their structure and dynamic. The morphodynamic evaluation has been carried out based on Tricart's proposition, taking into account the erodibility and the erosive intensity factors. The environments have been classified as stable, intergrades and unstable, and five degrees of vulnerability have been defined.

The main component analysis of the natural system took in consideration the lithologies, the regional structures, all sorts of genetic formations, kind of soil, as well the aspects related to the climate, vegetation and soil use.

The natural frame evaluated under this focus revealed a large diversity. Seven morphostructural domains, 15 geosystems and more than 100 geofacies have been identified, which include potentially rich environments, however, overall vulnerable, as seen in the physical support conditions and the complex relations between their biotic and abiotic components.

The reorganization of the international economy based on the globalization, a model of centralized, selective and intensive development, provoke radical changes in the productive structure with deep influence in the spatial organization and strong pressure over the weak coastal natural systems, with the possibility of losing the potential of this replaceable environment which support a genetic diversity of incommensurable scientific and economic value.

The predatory interventions of the natural resources, although with less intensity than the rest of Brazil, are still present in the Santa Catarina Coast, and getting worse, observing in some cases the risk of becoming irreversible.

The knowledge of the structure and dynamic of the natural frame establish a basic and preliminary stage for the subsequent management and monitoring activities. This, when done efficiently, composes a better foundation for programs dedicated to arrange/rearrange the coastal zone.

RECENT AND ANCIENT SEDIMENTS IN THE JAGUARIBE RIVER MOUTH AND ADJACENT AREAS: RE-DIMENSIONING THE ROLE OF THE AEOLIAN ACTION IN THE GEOMORPHOLOGICAL EVOLUTION OF THE EASTERN COAST OF THE CEARÁ STATE, NORTHEAST OF BRAZIL

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The eastern coast of the Ceará State, Northeast of Brazil, lies east of the Jaguaribe River, which drains the eastern and southern Ceará. The downstream segment of this river is a SW-NE orthoclinal valley inset in a wide <<inner lowland>> between the Precambrian basement to the west and the Middle-Upper Cretaceous 'Potiguar Basin' to the east. Its lower course turns westwards 40 km before reach the shoreline, where the oldest beds of the basin outcrop as non-continuous active seacliffs 20/30m high. The Cainozoic sediments have been mapped as 'Barreiras Group', a (Later Tertiary? Pleistocene?) deposit of torrential or fluvial continental clastics, locally represented by the 'Faceira Formation', a fluvial terrace that occurs along the west side of the river, and by the 'Barreiras Formation', which conceals the northeastern continuation of the basin, outcropping as lower seacliffs at the shoreline. Some publications stress the role of neotectonics in the orientation of the lower course of the river and in the contact Cretaceous and Tertiary sediments at the seacliffs. The identification of old dune deposits possibly interfingering with fluvial and lacustrine deposits, (Late Pleistocene or even older?) on the coast and inland, in the area mapped as 'Barreiras Formation', lead us to suggest that after have been excavated (Pleistocene lower sea-levels?) along strike the Cretaceous sandstone to the present coast or beyond, the lower course of the river migrated to the west as a result of dune damming, laterally eroding the north-east continuation of the Tertiary terrace. In the sequence, and in relation with last Pleistocene and Holocene high sea-levels, the valley has been filled by aeolian deposits and the shoreline exposed to coastal retreat, resulting in seacliffs cut into the dunes. This interpretation stresses the influence of Upper Pleistocene-Holocene dynamic related to coastal processes in the geomorphological evolution of the area.

GEOMORPHIC INDICATORS OF NET LONGSHORE DRIFT CELLS USING REMOTE SENSING: A REVIEW AND A NEW APPROACH

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Transport of sediments along the coast is termed longshore drift. Net longshore drift directions may change due to variations in coastal orientation, forming drift cells. Each drift cell is based on net uni-directional longshore movement of sediments over a long period of time, in spite of any lesser, seasonal, movement in the opposite direction. A drift cell comprises source (zone of erosion), transport corridor (zone of transport) and sink elements (zone of accumulation). Drift cells may begin and end in broad, poorly defined zones, and may vary from tens of meters to scores of kilometres in length. The systematic use of geomorphic and sedimentological indicators to determine net longshore drift cells along a coastline is a quick and accurate method with which to provide qualitative information to support an initial framework for coastal management decisions. Geomorphic indicators can be easily obtained either from comparison of aerial photographs (best scales and results) or satellite images from different years and seasons. However, because these remote sensing products represent just an instantaneous taking, they must be used with some restriction. Geomorphic indicators of net longshore drift cells comprise: natural and artificial structures interrupting longshore drift causing sediment accumulation against one side of the structure and erosion against other one; spit growth, stream mouth diversions and inlet migrations have the direction of net longshore drift; beach width, which increases in the downdrift direction; plan configurations of deltas and intertidal fans, and beach morphodynamics (including surf zone, longshore bars and beach cusps morphologies, embayments and tombolos) provide important information for determination of narrow or broad shore-drift cells; coastal dunes and bluff morphology and extent, and coastal erosion evidences along beach can also give good information about drift cells; suspend sediment plums and the angle that waves approach the shoreline indicate the direction of longshore current.

GEOMORPHOLOGIC ASPECTS OF THE AMAZON CONE OBTAINED THROUGH INTEGRATION OF BATHYMETRIC DATA

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The general shape of the Amazon fan has been established by numerous researchers mainly through the configuration of the isobaths, a technique inadequate to identify a spatial arrangement of topographic details of the fan surface. These have only been identified through the employment of long range side scan sonar (GLORIA) without bathymetric information and through swath bathymetry along only few channels of the drainage systems. The present work presents the results obtained through the integration of bathymetric data gathered during the expeditions of the Brazilian Program for the Delimitation of the Continental Shelf (LEPLAC Project) as also bathymetric data from public domain. Through the use of a computer program the ground surface was calculated and mapped as gradient and contour maps. In the gradient map contourlines were spaced at 50 m intervals. A very large depart between the 50 m and 100 m isobath indicate the low gradient of the continental shelf. Decrease in gradient of the distal end of the fan was also clearly evidenced. Considerable resolution was obtained through the contour map allowing the identification of the distributary channels as also evidence of mass movement of the upper cone. The middle cone was characterized by a lower gradient and geomorphic evidences of decrease in the intensity of geomorphic processes compared to the upper cone. A new reduction in the topographic gradient occurs at about 4200m depth, the limit between the upper and lower cone. The distal limit of the lower cone occurs in the proximity of the 4850m isobath, at the transition to the Demerara abyssal plain. The methodology was adequate to distinguish and characterize the geomorphic domains of continental shelf, slope and rise.

RESPONSE OF THE MANGROVES TO THE GEOMORPHOLOGICAL CHANGES ON THE SAO MATEUS RIVER MOUTH, ESPÍRITO SANTO, BRAZIL

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In the last decades of this century, the mangroves have been studied under several points of view, being aim of ecological, biological, geomorphological and social-economical researches.

In spite of the account given to the mangroves, these ecosystems suffer a lot of kind of impacts, mainly those induced by men. On the other hand, nowadays, the concern of scientific researches is directed on the losing of mangrove areas due to erosion and sedimentation processes as a consequence of the rise of the sea mean level. There are no doubt the ecological conditions of the mangrove to response to erosion and depositional events of the coastline, provoked or not by worldwide climatic changes.

This paper analyses the geomorphological and phytogeographical changes on the São Mateus River mouth, in Conceição da Barra, Espírito Santo (Brazil), between the years of 1970 and 1998. The mangroves are seen under the biogeographical point of view - helped by the most adopted methods in geomorphological research - which understanding of the distribution in time and space, is emphasized by the interrelation of the elements that composes the landscape, such as climate, hidrography, landform, soil and the man.

Based on methods elaborated by Ab'Sáber (1969) and Ross (1992) and conceptuals by Thom (1984), we tried to understand the causes of recent configuration of the São Mateus River mouth, and mainly, the distribution of the mangroves, through distitive scales and timing analysis.

In this way, the hidrographic complex of the São Mateus River is the largest spacial unit analysed, which geomorphological, climatical and land use characteristics are interpreted in a more abroaded form. A more detailed analysis is made at the Sao Mateus River mouth where the mangroves are studied as biological indicators of the erosive and depositional events, through their biotic and abiotic characteristics.

MORPHOLOGIC EVOLUTION IN THE ARARUAMA LAGOON, RIO DE JANEIRO STATE - BRAZIL

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The Araruama lagoon, covering about 220 km², is located at the northeastern region of the Rio de Janeiro State, at the Araruama, Sao Pedro d' Aldeia, Cabo Frio and Arraial do Cabo Counties.

Aspects of the external and internal morphology suggest that the evolution of the lagoon is related to sea transgressions and regressions during the Quaternary.

Pre-Flandrian continental deposits are cropping out on the southern border of the lagoon conforming also its sandy bottom, which are remainder of an intense erosion caused by two fluvial systems flowing from the northwestern (Palmital Hill) and northern areas (Mirim and Sapiatiba Hills).

During the Flandrian transgression (14,000 to 7,000 years BP) the sea had invaded the former small sedimentary basin from the east and south areas, favouring the gradual deposition of sands and interbedded sandy coquinas. At the end of the Flandrian transgression (7,000 years BP), regressive events would have produced the Cabo Frio plain, the beach ridges and the internal marine barriers, forming a number of small lagoons into the last two morphological units.

The lowering of the sea level, related to the regression, continued till reaching the negative 25 meters level (in 6,500 years BP) and the sedimentary basin of the actual lagoon became exposed to a new erosion process. Mainly, as a consequence of an increase of humidity related to heavy rains, the fluvial system coming from the northwest was reactivated, producing a strong erosion of the lagoon sediments along an east-west oriented channel showing a canyon like morphology.

A new transgression of the sea, known as Dunkerquian, started at 6,000 years BP, reaching its maximum altitude of 2 meters (in 4,500 years BP), was followed by a regressive event at 3,500 years BP. These transgressive and regressive action of the sea would have produced the deposition of sandy sediments as external barriers and the closure of the connection of the canyon with the sea. The barriers are those known as Restinga de Massambaba and Cabo Frio, that caused the formation of the Araruama lagoon with more than 15 meters depth and linkage with the sea throughout the Itarujú 2-4 m depth tide-channel. At the bottom of main channel of the remainder canyon, modern laggonal organic muds have been detected.

ISLAND VOLCANIC ACTIVITY AND COASTAL ENVIRONMENT RESPONSES-EXAMPLE FROM COMPARITIVE STUDIES

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The volcanic eruption during Holocene of Hainan Island, China, has elevated the coastal bays to be terraces, blocked the river mouths, forced river channels migration and elevated the abundant river mouths to be deep erode-meandered bays, and volcanic rocky coast offered the basements for coral reef development. The volcanic activities have changed coastal landforms, slopes, dynamic conditions, sedimentary characteristics and the trends of coastal evolution. The development of volcanic coast has shown a multi-affection of both inner and outer dynamic processes of tectonic, marine hydro-dynamics and biological factors. Comparatively, Hawaii volcanic coast is characterized by a volcanic-island chain formed by the lateral movement of the oceanic plate moving over a stationary hot spot. The ages of the islands increase toward the left, and new islands will continue to form over the hot spot. Recently, lava flows of Kilauea eruption continue the island-building processes, produce a barren volcanic landscape of crater bay, lagoon etc., that served as a foundation for coral reefs and lives: plants, animals and humans. Also, the eruption has changed the local atmospheric environment. Plants, animals and humans. Also, the eruption has changed the local atmospheric environment. Plenty precipitation of the tropic islands develops fertilized soil, which produces favorable condition for luxury forests and bio-diversity. The Pacific volcanic islands are the precious location of tropic biological resources and ecological environment. Volcanic debris daily erupted by active volcano of Sakura Island, Japan have buried the parts of island, highways, houses, temples, and have caused muddy flow disasters often, especially during thunder storm periods, as a result, they have changed the dynamic processes. What is more important, besides the change of coastal geomorphology, dynamic processes and the trend of coastal evolution, is that the volcanic activities might lead to a series of severe disasters.

Abstracts **delivered at IAG 1999 Regional Conference on** **Geomorphology**

SESSION: Soils and Geomorphology

1. OXISOLS/SPODOSOLS SYSTEMS: INFLUENCES ON THE DISTRIBUTION AND GENESIS OF DEPRESSIONS IN THE LOW COURSE OF JAU RIVER, AMAZON BASIN
2. LANDSCAPE EVOLUTION OF A SOIL SEQUENCE IN PIRACICABA (SÃO PAULO), BRAZIL
3. DETERMINATION OF SOIL-WATER MATRIX POTENTIAL IN TWO DIFFERENT SOILS (LE and PE) THROUGH TENSIMETERS OF MERCURY MANOMETER, AT THE NORTHWEST AREA OF PARANA STATE - BRAZIL
4. INFLUENCE OF TOPOGRAPHY IN SPATIAL VARIABILITY OF TEXTURE, THICKNESS AND PROFILE DEVELOPMENT IN MOUNTAIN SOILS
5. GEOMORPHOLOGY AND SOILS OF THE PEREIRA-CARTAGO'S REGIONS OF COLOMBIA AFFECTED BY TECTONIC MOVEMENTS
6. THE GENESIS OF EROSION AT THE HEADWATERS IN THE NORTHWEST AREA OF PARANA STATE - BRAZIL
7. CONSIDERATION ON SOIL FORMATION BY PORE SIZE DISTRIBUTION PROPERTIES
8. CORRELATION BETWEEN GEOMORPHOLOGY AND SOILS OF THE REGION OF LAVRAS, MINAS GERAIS, BRAZIL
9. PEDOGENESIS AND GEOMORPHOLOGY OF A SOIL SEQUENCE FROM THE TERTIARY PLATEAU TO THE ALLUVIAL PLAIN OF THE SOLIMÕES RIVER, CENTRAL AMAZONIA
10. OCCURRENCE OF PALEOSOLS FROM COLLUVIUM AND ELLUVIUM WITH UMBRIC EPIPEDONS IN MOUNTAINOUS AREAS IN RIO DE JANEIRO STATE, BR: SITUATION, PROFILE DESCRIPTION AND PEDOLOGICAL CHARACTERISTICS
11. SEQUENCES OF SOIL PROFILES WITH UMBRIC EPIPEDONS CHARACTERISTICS IN BONITO RIVER BASIN, PETROPOLIS, RIO DE JANEIRO, BRAZIL
12. PREDICTIVE MODEL FOR SPATIAL DISTRIBUTION OF SOIL CREEP DEPOSITS
13. PHYSICO-HYDRIC CHARACTERISTICS STUDY OF A PEDOLOGICAL SYSTEM AT THE NORTHWEST AREA OF PARANA STATE - BRAZIL
14. MINERALOGICAL CHARACTERIZATION OF CAMBISSOLOS IN MOUNTAINOUS AREA (RIO DE JANEIRO STATE - BRAZIL)
15. GEOMORPHOGENESIS ROLE IN THE EVOLUTION OF WEATHERING PROFILES DEVELOPED ON GNEISSES IN RIO DE JANEIRO, BRAZIL

16. GEOPEDOLOGICAL SYSTEMS IN THE IBITIPOCA STATE PARK, MINAS GERAIS STATE, BRAZIL
17. GEOMORPHOLOGY AND STRATIGRAPHY IN ANALYSIS OF SURFACE WATER EROSION SUSCEPTIBILITY - PARAÍBA DO SUL RIVER MIDDLE VALLEY (SAO PAULO / RIO DE JANEIRO - BRAZIL)
18. SOIL CARTOGRAPHY USING A COMBINATION BETWEEN A SOIL INVESTIGATION TECHNIQUE (THE STRUCTURAL ANALYSIS) AND A LANDSCAPE INFORMATION (DERIVED FROM DEM)
19. GEOMORPHOLOGY AND DARK SUPERFICIAL HORIZONS IN A SMALL WATERSHED IN "SERRA DO MAR" (PETRÓPOLIS - RIO DE JANEIRO STATE - BRAZIL)
20. GENESIS OF HUMIC OXISOLS AND ITS RELATIONSHIP WITH THE EVOLUTION OF THE LANDSCAPE OF A CRATONIC AREA IN THE SOUTH OF MINAS GERAIS STATE, BRAZIL
21. RELIEF, SURFACE DYNAMICS, AND SOILS OF THE SERRA DO MAR (UBATUBA, SAO PAULO)
22. HOLOCENE AND PLEISTOCENE PALEOSOLS AND POST-EUROPEAN COLONIZATION EROSIONAL DEPOSITS IN THE SERRA DE SÃO JOSÉ (MINAS GERAIS BRAZIL)

OXISOLS/SPODOSOLS SYSTEMS: INFLUENCES ON THE DISTRIBUTION AND GENESIS OF DEPRESSIONS IN THE LOW COURSE OF JAU RIVER, AMAZON BASIN

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This work has been developed in the National Park of Jau, middle course of Negro River, Amazonas State. On a map constructed from aerial photographs and satellite images, covering around 190 km² of the study area at scale 1:80 000, it has been identified 9 geomorphological units:

1. Plateau presenting relief of gentle hills on the edges (corresponding to forest vegetation);
2. Proto-depression at 1st stage of development (zones with slight deficiency of drainage covered by forest
3. vegetation);
4. Proto-depressions at 2nd stage of development (corresponding to high campinarana vegetation);
5. Proto-depressions at 3rd stage of development (corresponding to low campinarana vegetation);
6. Depressions (corresponding to campina vegetation);
7. 1st floodplain;
8. 2nd floodplain;
9. Terraces and
10. Paleochannel.

In the area of field study a transect survey heading south was executed along 4 300m, from the right margin of Jau River until the zone of depressions of the Jau - Carabinani divide. The units of geomorphology and vegetation as well as the soil information acquired with the auger were placed along the topographic profile obtained. It was noticed good correspondence between soil, vegetation and geomorphology features. The last 230m were studied in toposequence, with 11 points of auger sounding and 3 trenches placed from the top of a gentle hill, covered by forest, to the depression, covered by open vegetation (campina). The data shows the existence of a oxisol/spodosol system, where the last one develops, from downslope to upslope, at the expenses of the first one and, locally, of the sandstone of Formação Prosperança. This transformation is related to the clay, iron and organic matter exportation, and might explain the lowering and the morphology of the relief.

LANDSCAPE EVOLUTION OF A SOIL SEQUENCE IN PIRACICABA (SÃO PAULO), BRAZIL

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An area inside the Paulista Peripheral Depression (Sao Paulo, Brasil) contains a sandy Cenozoic deposit overlying a silty Permian deposit of the Iratí formation (Pi). This sequence is abruptly interrupted by a diabase sill overlain by a red clay which extends westward towards the Piracicaba River. These materials are separated by two stonelines made up of rounded quartzite pebbles. Two hypothesis were considered to explain the local landscape evolution: a local "in situ" evolution and a Quaternary tecto-morphoclimatic evolution. The sandy and red clay deposits could be considered as "in situ" formations derived directly from the local parent material, a sandy Triassic-Jurassic deposit of the Piramboia formation (TrJP) and the diabase, respectively. On the other hand, the local Paleo-Mesozoic stratigraphy shows that, if this hypothesis is considered, a whole stratigraphical layer corresponding to a late Permian clayey deposit of the Corumbatai formation (Pc) would be missing. This is possible in areas where erosive discordances are identified, which is not the case of this study area. Climatic changes during the Quaternary, leading to alternating periods of erosion and pedogenesis, were considered as the best hypothesis to explain this area's landscape evolution. In this way, two depositional events were considered. The first event was the deposition of a fine sandy sediment in the form of stepped alveoluses during a first erosional period. Excavations of the Paulista Peripheral Depression exposed a sill barrier that stopped these sediments that were transported from higher landscape positions. The second depositional event, leading to deposition of the red clay, was probably due to an incision of the first event's pediplane followed by a second pedimentation process during a later erosional period. The origin of the stonelines was related to these depositional events due to the fact that they separate materials that present lithological discontinuities and the high degree of pebble roundness would result from the high friction these materials suffered during transport rather than "in situ" geochemical formation processes.

These stonelines could be interpreted as been formed by geochemical processes and have an autochthonous origin. The first hypothesis confers an autochthonous origin to both stonelines where the rounded pebbles could be formed by geochemical processes. This is possible but to the very high degree.

At least two post-Permian depositional events were identified as marked by stonelines; one of rounded pebbles separating the fine sandy Cenozoic layer from the basal silty Permian base deposit and a second stoneline separating the diabase and part of the Irati formation saprolites from the red clay.

Lithological discontinuities in four profiles on each of the parent materials were identified through the granulometry of sand fractions, elemental analyses of Zr and Ti, semi-quantitative determinations of quartz and micromorphological observations. The first post-Permian depositional event is indicated by an abrupt lateral transition between the diabase and the sandy sediments. Significant differences in the granulometry of sands, the quantities of Zr and Ti, the Ti/Zr and Zr/quartz ratios and the degree of roundness of the quartz grains were observed between the materials above and below the second stoneline, indicating its allochthonous origin and the presence of a second depositional event.

DETERMINATION OF SOIL-WATER MATRIX POTENTIAL IN TWO DIFFERENT SOILS (LE and PE) THROUGH TENSIMETERS OF MERCURY MANOMETER, AT THE NORTHWEST AREA OF PARANA STATE - BRAZIL

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It was studied the soil-water matrix potential of a dark reddish Latosol and a dark reddish Podzolic soil, respectively placed at the upper and at the middle slope of Campus do arenito topsequence in Cidade Gaúcha town - Northwest of Paraná State. This determination was made through tensimeters of mercury manometer, through daily readings at 7:30, 13:00 and 18:00 o'clock, summer of 1999, at 10, 20, 30, 50, 70, 90, 120 and 150cm of depth.

After a period of 10 days of drought, a drizzle of 5 mm/h didn't increase the soil-water matrix potential, happening at 10 mm/h only, for both soils, in the latosol up to 20cm and in the podzolic soil up to 120 and 150cm of depth. When it rained 30 mm/h the matrix potential increased up to 70cm in the latosol, being linear at 90 and 120cm, increasing to 150cm again, and in the podzolic soil it remained relatively linear, indicating good field capacity.

The contrast between those two soils can be explained the texture, structures and total porosity difference of Bw and Bt horizons; through the topographical position in the slope; through their exhibition to climatic agents, which are intense in the latosol, without good vegetable covering and being mild in the podzolic soil which is covered with sugar-cane.

Such behavior was considered important for the evaluation of the hydric circulation, over all lateral and larger in PE and downslope, in fact, that could contribute to the largest erosive susceptibility of slopes with such distribution of soils.

INFLUENCE OF TOPOGRAPHY IN SPATIAL VARIABILITY OF TEXTURE, THICKNESS AND PROFILE DEVELOPMENT IN MOUNTAIN SOILS

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In steep mountain areas, where gravity-assisted geomorphologic processes are very intensive, topography influences quite closely a number of soil characteristics.

The Geographical-Information-System (GIS) supported analysis of topographic factors derived of the Digital Elevation Model, such as slope, curvature, and cumulated flow surface, shows the relationship between those factors and the development degree of soil profiles, thickness and fine element content in soils.

The model and result validation has been made by studying the soils of the Valle de Perlunes (Cantabrian Mountains, North of Spain) with samples taken from 56 soil profiles, opened on soils developed on five different substrates: sandstone, dolomías (dolomite), slates, limestone and coluviones. Soil horizons have been identified in these profiles and parameters such as thickness and fine element content have been measured, specifically the fraction of sizes below 2 mm. The associated changes of soil parameters and topographic factors have been quantified with multiple regression analysis.

The maturity degree interpreted as a function of the number of developed horizons, increases in the slope areas of concave morphology, soft slopes, and receiving abundant running waters. In similar areas, also with soft slopes and receiving abundant running waters, with no concavity increasing, only an increase of soil thickness has been registered. Topography also influences the proportion of fine elements in soils, which increases when slope steepness decreases.

The implementation on a GIS of the relationships established between topographic factors mentioned and soil characteristics enables the generation of models regarding thickness spatial distribution and abundance of fine particles in soils, which means an important contribution to the problem of soil cartography in mountain areas.

GEOMORPHOLOGY AND SOILS OF THE PEREIRA-CARTAGO'S REGIONS OF COLOMBIA AFFECTED BY TECTONIC MOVEMENTS

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The geomorphology and soils of an area located between the cities of Pereira and Cartago in Colombia with an approximate surface of 25.000 ha, was studied. The area goes far from the Central Mountain of Ande's chain till the Cauca river valley, a tectonic depression which makes links with the Occidental Mountains of Ande's chain. The area was divided in three climatic grounds beginning with the temperate humid climate lands (Th) that reaches to 10.8% of the whole area with temperatures between 19.4 and 24.9° C. The year average precipitation are about 2173 milimeters with heights varying from 1250 to 1350 meters. Within that climate unit were differentiated an extensive aggradational geoform known by "Dissected Hidrovolcanic Piedmont". The main kinds of soils occurring in it belong to the Inceptisols Order. This large geoform overcome the limits of the humid temperate climate reaching the domains of the less humid temperate climate lands (Tu). Here, the heights are between 1250 -1000m and occupy 44% of the whole area, where the landscapes are identified as "Body and Base of the ancient Alluvial Fan buried with volcanic ash". In these positions the soils are respectively Ultisols, and Alfisols Molisols Inceptisols and Entisols. Another geoform that appears in this situation is the "Mountain and Hilly's relief of Santa Barbara's chain". The end of the area is located in a warm-dry climate lands (Wd) and makes 45.2% of the whole area with heights below 1000m. The temperatures are in the range of 26.4 - 23.3°C and the year average precipitation is 1614 milimeters. The main geoforms are the "Complex Piedmont of Santa Barbara's Mountain" with soils as a Alfisols, and the "Alluvial Valleys" of the Cauca and La Vieja rivers respectively with Molisols and Entisols.

THE GENESIS OF EROSION AT THE HEADWATERS IN THE NORTHWEST AREA OF PARANA STATE - BRAZIL

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Erosive processes are very common in the northwest area of Parana State, in Caiua sandstone site. Processes such as: gullyng, soil mass movements and losses of soils by runoff. Such processes are related to the pedological covering organization (structure) and its landuse. To research the genesis of such processes in headwater areas, where gullies frequently develop, it was chosen a local, partially preserved, landscape unit. The data collecting of pedological covering, through four soil topsequences, showed two types of slope morphology and that there's a specific pedological system associated to each slope. Above the source, slopes are convexo-concave, covered by dark reddish latosol - quartz sands - gley; the slopes directly related to the drainage axis are convex and they present a pedological system composed by dark reddish latosol - dark reddish podzolic soil - quartz sands. From upper to down slope, a superficial horizon of sandy texture thickens becoming a volume of about 2m of thickness (quartz sands) near the source. When vegetation is diminished, it facilitates the erosive processes and then, through regressive erosion, reaches the upper slope sections. In outlying suburbs, the erosive processes are set in drainage headwater because, besides the fragility of soils, pluvial waters of paved roads are concentrated and poured out overthere.

CONSIDERATION ON SOIL FORMATION BY PORE SIZE DISTRIBUTION PROPERTIES

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Soil formation processes can be characterized by soil pore properties. As soils develop more, the quantity of larger pores increases, consequently increasing the total porosity and changing pore size distribution. Since the larger pores are created by biological activities, spatial variability of the larger pores becomes higher during the soil formation processes. The objective of this study is to analyze the spatial variation of the pore size distribution to investigate soil formation. The sampling site is located within a 1-yr old Erva Mate (*Ilex paraguariensis*) plantation area at the Caguiri Farm of UFPR, Curitiba city - PR, Brasil. Soils are Inceptisols. Along the hillslope line and the line perpendicular to it, 54 and 41 undisturbed soil samples of 100 cm³ volume, respectively, were taken from 0-5 cm depth which is a part of A-horizon. The membrane suction method was adopted to determine a retention curve for each sample. The suction values in the method were 0, 4, 7, 10, 20, 30, 40, 50 and 60 cmH₂O. Considering these values and the Laplace equation, the pore sizes were classified as, >750, 750-429, 429-300, 300-150, 150-100, 100-75, 75-60, 60-50 and 50 mm. The last range constitutes microporosity. Geostatistics analysis (autocorrelation and semivariance) did not show the tendency and frequency of spatial variability of pore distribution properties. The values of coefficient of variation decreased with the pore size. This indicates that larger pores have larger spatial variation. This implies that soil formation process occurs by the increase of the heterogeneity of parent materials with regard to pore size distribution.

CORRELATION BETWEEN GEOMORPHOLOGY AND SOILS OF THE REGION OF LAVRAS, MINAS GERAIS, BRAZIL

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The work used the correlation between geomorphological features and soil formation to evaluate and map soils of the region of Lavras, MG, differentiating classes of soils with argillic B horizons. The study area was limited by geographic coordinates 21°10'23"/21°19'22" S and 45°04'36"/45°33'23" W, comprising portions of topographic sheets of IBGE: Nepomuceno, Carmo da Cachoeira, Lavras, Itumirim, Nazareno e Itutinga, scale 1:50.000. The geomorphological features were assessed on the basis of slope classes with five selected slope gradients: nearly level - 0 - 3%; gently sloping - 3 - 12%; strongly sloping - 12 - 24%; moderately steep - 24 - 45 %; and steep - > 45%. Using a GIS the map of slope classes of the region was generated. The model of soil distribution in the landscape was exhaustively checked by sound field work. The most relevant soil profiles were described according to Lemos & Santos (1984). Physical and chemical analyses were carried out to enable precise classification of these soils. The results showed Latossols occurring on nearly level and gently sloping surfaces. Hydromorphic and Alluvial soils were found in the class nearly level, with slope gradient of 0 to 3%, but at different parts of the landscape, related to flooding plains and terraces. Within the slope classes strongly sloping and moderately steep (12 to 24% and 24 to 45%) four classes of soils with argillic B horizons were mapped: Yellow-Red Podzolic, Dark Red Podzolic, Dusky Red Podzolic and Reddish Brunizem. These were separated using the correlation between soil formation and geology. In the slope class steep (slope gradient > 45%) occurred Cambic and Litholic soils. On the basis of this correlation and using a GIS, a Soil Map of the Region of Lavras, differentiating soils with argillic B horizons was produced.

PEDOGENESIS AND GEOMORPHOLOGY OF A SOIL SEQUENCE FROM THE TERTIARY PLATEAU TO THE ALLUVIAL PLAIN OF THE SOLIMÕES RIVER, CENTRAL AMAZONIA

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Six soils ranging from the Tertiary Plateau down to the Solimões valley in Iranduba, near Manaus (AM) were studied. These selected soils were classified as Yellow Podzolic with Antropic A horizon ("Terra Preta de Índio) (P1), plinthic Red-Yellow Podzolic (P2), Yellow Latosol (P3), Eutric Low-Humic Gley (P4), Eutric Alluvial (P5) and Eutric Hydromorphic Soil (P6); the latter three soils were taken from the Alluvial Plain. Surface and subsurface samples were submitted to chemical, physical and micropedological analysis. The three soils from Tertiary Plateau (P1-P2-P3) were generally dystrophic, with high levels of Al³⁺ and dominated by kaolinite in the clay fraction, similarly to those developed from Tertiary Plateau pre-weathered sediments elsewhere in Brasil. On the other hand, the antropic surficial A horizon of the Yellow Podzolic showed a distinct eutrophic character, with high base saturation and very high soluble P content. The high silt content of the Alluvial Plain soils (P4-P5-P6) and great variation of the texture with depth is due to the complex sedimentary history of this environment with weak weathering compared with the Tertiary Plateau upwards. The soils from the alluvium were typically high activity clays-dominated, and some horizon had high levels of exchangeable Al, associated with 2:1 expansive clays. This points to an increasing present weathering and destabilization of the smectite under present conditions. The presence of petro-plinthite in the transition segment of the Tertiary Plateau was attributed to lateral Fe-flux and its precipitation along the slope break down to the alluvial flatlands. The soils on Tertiary sediments showed higher levels of carbon organic, compared to those in the alluvium, due to the dystrophic and less favourable conditions to the mineralization. The higher values of Fe-oxalate/Fe-DCD, between 47 and 73 in the soils from the Alluvial Plain indicate the dominance of less crystalline form of the Fe-oxides and relative immaturity of the soils, compared with those upwards. The role of the geomorphic evolution and the soils position along the slope of this sequence is clearly demonstrated, illustrating the importance of pedogeomorphic units along the contact "Terra Firme" - "Várzea" across Central Amazonia as a key feature for the environmental comprehension.

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OCCURRENCE OF PALEOSOLS FROM COLLUVIUM AND ELUVIUM WITH UMBRIC

EPIPEDONS IN MOUNTAINOUS AREAS IN RIO DE JANEIRO STATE, BR: SITUATION, PROFILE DESCRIPTION AND PEDOLOGICAL CHARACTERISTICS

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Some mountainous areas where the average elevation exceeds 800 metres the climatic characteristics are influenced by the topographic and vegetal cover factors that are responsible for temperature decreasing and humidity values increasing. These characteristics seem to have reunited conditions in the past to the umbric epipedons development.

Being dynamic environments in relation to slope processes action, pedogenic material successions and soils as such with complex genesis and composition are common. In the most of the cases they occur in low hills, mainly in hollows.

Some paleosols (developed from colluvium and elluvium) overlapped by colluvium materials and soils were studied in mountainous areas of Bom Jesus do Itabapoana and Petropolis municipalities.

A great part of the paleosols analysed presents soil characteristics related to Oxic horizons. These paleosols have relatively preserved umbric epipedons that are not so thick than those ones of the soil profiles or pedogenic colluvium that are over them. There are also common paleosols that are directly overlapped by organic materials possibly removed from the slope (pedogenic material?).

A reduced number of the analysed sections showed paleosols formed from elluvium recovered by pedogenic colluvium or directly by organic materials being the majority Cambic horizons.

The main characteristics of these paleosols are the presence of an umbric epipedon with variable thickness due to the decapitation level of it; 10YR and 7.5YR dominant hues with very dark values and chromas; friable consistence, slight plastic or non-plastic and non-sticky and slightly sticky; high organic carbon and organic matter contents (generally upper than 11% for the last one); almost always under 4.5 pH values; average values upper than 50% for Al; medium and clay texture, with about 35%.

In relation to the B horizons, those ones with Oxic horizons characteristics present 7.5YR as dominant hue with values and chromas upper than 5; friable and slightly hard consistence, generally sticky and slightly plastic and plastic; clay and very clay texture; pH above 5 and high Al values; ki and kr relations under than 1.8 in the majority; and quartz domains in the sand fraction mineralogy.

SEQUENCES OF SOIL PROFILES WITH UMBRIC EPIPEDONS CHARACTERISTICS IN BONITO RIVER BASIN, PETROPOLIS, RIO DE JANEIRO, BRAZIL

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The study area is located in Serra dos Órgãos "steps" (Serra do Mar) that are the Bonito River Basin interstreams divides. The scarped sierras, steps, very dissected hills and carved valleys compartments, characterize the landforms.

The regional climate is the mesothermic rainy tropical one. In relation to the basin, the climatic conditions are affected by the elevation (averages upper than 900 m) and the slope position and vegetal cover as well.

Soil profiles with umbric epipedons were analysed in toposequences in the upper and middle slope, elevated valleys and valley floor formed from elluviums, colluviums and alluviums.

The upper slope soil profiles formed from elluviums present B cambic horizon characteristics. And in relation to the middle and down slope soil profiles, there are two situations. The first is about a pedogenesis developed from colluviums with B cambic and B oxic horizons characteristics being the former ones located in the upper sections of the middle slope and the last ones in down sections of it. And the second situation is about pedogenic colluviums with incipient pedogenesis. In some cases analysed for these two situations, these soil profiles are on paleosoils with umbric epipedons.

The soil profiles formed from alluviums are situated in two sections: elevated valleys and valley floor. The former ones have characteristics that correspond to Alluvial Soils and soil with B cambic horizon from fluvial terraces; the second ones have gley horizon characteristics.

The main characteristics of these umbric epipedons in soil profiles from elluviums, colluviums, and alluviums are: considerable depth (reaching 145 cm in some cases); 7.5 YR dominant hue, with values and chromas between 3 and 2; high organic carbon values (upper than 6.0 in average for soils in the slope and upper than 3.0 for soils in the valley) and organic matter content (reaching about 16.0) tending to decrease in depth; base saturation values under than 50%; and pH values under than 4.5 for the majority of the analysed horizons.

The present topographic position of these soils and most recent transported materials and their physical and chemical characterization as well are important to the explanation of the present and recent slope process action and the landform evolution in these areas.

PREDICTIVE MODEL FOR SPATIAL DISTRIBUTION OF SOIL CREEP DEPOSITS

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The mapping of regolith is a very important technique necessary for many soil uses and planning applications. However, the scarcity of outcrops usually hampers the mapping by direct field or photo-interpretation surveys, and the mapping must be supported by topographic and geomorphologic interpretations. In order to quantify the topographic variation and to analyse the statistic relationships between topographic variables and regolith thickness we have developed a technique that uses Digital Terrain Models (DTM). This technique allows the analysis and implementation of a spatial distribution model of regolith thickness, based on construction of automatic maps.

In order to test and validate this methodology we have applied it to a geological and geomorphologic homogeneous area of the N-Iberian coast, near the village of Villaviciosa (Asturias). The lithologies of the substratum are mostly marls and sandstones of Jurassic age and the relief is characterized by gentle slopes modeled on an elevated old submarine erosion surface. In this area, the humid and temperate climatic conditions have produced a dense and continuous vegetation cover. In this conditions, the thickness of the regolith is mostly related to accumulations by soil creep in the zones of gentler dip and in the lower parts of the slopes.

The statistic analysis based on slope values, elevations, sun radiation, cumulative flow and concavity values, using 60 sample points, indicates a probability for the presence of more than 0.25 m thick regolith. The obtained regolith distribution model was validated using 84 new sample points and its accuracy was compared with other regolith thickness map obtained by traditional field survey and photo-interpretation. The methodology developed provides a competitive way to obtain reliable information about regolith thickness and its spatial distribution, that is an important information in geographical data bases for environmental and planning purposes.

PHYSICO-HYDRIC CHARACTERISTICS STUDY OF A PEDOLOGICAL SYSTEM AT THE NORTHWEST AREA OF PARANA STATE - BRAZIL

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This study was accomplished in the microbasin of Bom Jesus stream, in Cidade Gaúcha town, at the northwest area of Parana State - Brasil. It aimed to characterize a physico-hydric performance of a dominant pedologic system in such area, which is constituted of dark reddish Latosol (LE), dark reddish Podzolic soil (PE) and quartz sands (AQ), distributed along the slope.

The vertical and lateral morphologic characterization of the horizons along the representative topsequence was proceeded, followed by infiltration measures through mult-disk infiltrometer (unsaturated hydraulic conductivity or K) and then granulometrical analyses.

The results revealed that K is elevated and relatively constant in LE at the upperslope, lightly decreased in depth at Bw; smaller in PE, different in the profile, diminished in surface through landuse compaction and the presence of the Bt horizon, associated to the clay and microporosity increase; notably increasing downslope, both at surface horizons (A, E) and their contact with Bt, promoting the development of thick washed sandy horizon which will turn into AQ.

Such performance was attributed to the morphologic differentiation of the pedologic system, where the hydric flows seem to be harmonious to the current slope, allowing it to be interpreted as a lateral pedologic transformation and associated to a strong linear erosive susceptibility.

MINERALOGICAL CHARACTERIZATION OF CAMBISSOLOS IN MOUNTAINOUS AREA (RIO DE JANEIRO STATE - BRAZIL)

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The studied area is located in Serra do Mar, Petropolis municipality (RJ), in the southeastern region of Brasil, between the coordinates 22°15' and 22°29' S, and 43°00' and 43°10' W. The aim of this paper is to verify the mineralogical evolution presented in Cambissolos in the Brazilian Classification System (Inceptisols - Soil Taxonomy). This research is part of a project where different types of soils have been studied in distinct local geomorphic features to analyze the relationship between soil, relief and drainage. The studied pedons are in three different local geomorphologic compartments. Profile 6 is located at south where steep hillslopes and rock walls are observed and the pluviosity is around 2.800mm/year. Profiles 12 and 13 are located at west where the altitudinal variation is not so great (very steeply sloping to precipitous relief) and the pluviosity is around 1.600mm/year. Profiles 10 and 11 are located at north, where the relief is moderately steeply sloping and the pluviosity is about 1.000mm/year. X-ray diffraction (XRD) was taken in clay, silt and sand fractions samples for each horizon of the profiles. Differential Thermal and Thermogravimetric analysis were also taken to evaluate the kaolinite and gibbsite percentages presented in the B horizons. The mineralogy identified in clay fraction is: kaolinite, gibbsite, vermiculite, illite and goethite. In silt fraction is: quartz, feldspar, goethite, gibbsite, kaolinite, vermiculite and illite, and in the sand fraction, quartz, feldspar, gibbsite and illite/mica. A probable sequence of mineralogical transformation is shown for the profiles: 6, 12 and 13: feldspar»kaolinite»gibbsite; 10 and 11: feldspar»gibbsite, feldspar»kaolinite. In relation to the evolution or the weathering level of the Cambissolos it is possible to define a relative cronosequence: 13<12<6<11<10.

GEOMORPHOGENESIS ROLE IN THE EVOLUTION OF WEATHERING PROFILES DEVELOPED ON GNEISSES IN RIO DE JANEIRO, BRAZIL

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There have been studied two weathering profiles developed from gneisses in the State of Rio de Janeiro, placed in areas of distinct geomorphology compartments. The "Caxias profile", developed from the weathering of gneiss migmatitic, has been collected in the district of Duque de Caxias, in an area with "round hills" from the "Guanabara lowland". The "Furnas profile", developed from the weathering of biotite gneiss, placed in the district of Rio de Janeiro, at the Tijuca's massif in an accidented relief. The chemical and mineralogical studies allowed evidencing the importance of geomorphogenesis in the weathering and pedogenesis process. The "Caxias profile" presents caulinite associated to traces of goethite, halosite and illite in the whole profile (alterite and latossol) and gibbsite only in the pedologic horizons, while in the rock horizons the prevalence is of feldspar, quartz, illite/mica associated to traces of caolinite. The "Furnas profile" is characterized for presenting caolinite and illite/mica in the whole profile, while in the rock levels, feldspars, quartz and illite/mica are the predominant minerals. The chemical analysis evidence a smaller leaching of the mobile elements (Na₂O, K₂O, CaO, MgO) in the "Furnas profile" when compared to the strong exit of the mobile elements in the "Caxias profile". These data are in total agreement with the evolution of the two areas, characterized by the constant rejuvenation of the relief in the "Tijuca's massive" and a larger stability in the area of Duque de Caxias

GEOPEDOLOGICAL SYSTEMS IN THE IBITIPOCA STATE PARK, MINAS GERAIS STATE, BRAZIL

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The Ibitipoca State Park, located south of Minas Gerais State in Brasil, preserves important remanescents of the Mata Atlântica Brazilian ecosystem, showing wonderful geological formations along with endemic vegetational species; both has suffered many environmental impacts due to the turistic actions, because inexistent management plans or environmental zoning to discipline the visitations. It is showed the model of geopedological systems, a way to study and separate different pedogeoenvironments. The geological history has imprinted differential weathering and tectonic features in the rocks of the park, represented by saccharoidal quartzites, as well as "islands" of mica schist. In the quartzite dominion, the geomorphology is determined by the physical characteristics of the rock, as well as its structural features (tectonic control), originating shallow soils, due to the reduced relation pedogenesis/erosion, and accentuated relief. Litholic and cambic soils occur, predominantly the first ones, with high acidity and poor nutrient status. The schist rock doesn't show structural control on the relief, but instead, a climatic control, with smooth surfaces, originating clayey soils, and a more elevated reason pedogenesis/erosion, with well developed B and C horizons along the geopedological system. Over the schist occurs cambic soils, with a forest cover that maintains organic horizons at the soil surface, showing also stone lines in the C horizon.

GEOMORPHOLOGY AND STRATIGRAPHY IN ANALYSIS OF SURFACE WATER EROSION SUSCEPTIBILITY - PARAÍBA DO SUL RIVER MIDDLE VALLEY (SAO PAULO / RIO DE JANEIRO - BRAZIL)

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In the last decades integration between Geomorphology and Pedology has been used for landscape evolution research, resulting in soil-geomorphic models, some of them also considering stratigraphic aspects. However, little emphasis has been given on the application of these models to erosion processes studies, which methods generally take pedologic properties more important than geomorphological characteristics of soil sites, or even than soils space-time relationships. At the present study a methodology integrating pedologic attributes into geomorphologic and stratigraphic knowledge concerning Quaternary landscape evolution in hilly landforms of Southeastern Brazilian Plateau is used for surface water erosion investigation. The approach takes amphitheater-like headwaters as a basic geomorphological and pedological unit, where sedimentary successions are identified and mapped, on which are recognized complete or truncated pedologic profiles.

Five amphitheater-like headwaters were selected, being identified Quaternary allo-units by stratigraphic sections and drilling, mapped considering their morphostratigraphic importance. Based on spatial distribution of surficial deposits and on the relationships with geomorphic components of headwaters, sampling points were selected for texture, flocculation ratio, aggregate stability in water, porosity, bulk density and organic matter analysis of surficial (0-15cm) and subsurficial layers (15-30cm). The results demonstrated that surficial deposits with same pedologic classification present differences in aggregates size and micropores amount - pedologic properties observed as significant in definition of surface water erosion susceptibility. This susceptibility is also controlled by local topographic characteristics and by geomorphic setting inside amphitheater-like headwaters. In addition, recent depositional units showed significative variations according to re-working materials (weathered bedrock and/or older Quaternary deposits).

Therefore, the use of Geomorphology and Stratigraphy represents an important approach to erosion studies on hilly domains of Southeastern Brazilian Plateau, supplying more precise data for definition of erosion risk areas.

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SOIL CARTOGRAPHY USING A COMBINATION BETWEEN A SOIL INVESTIGATION TECHNIQUE (THE STRUCTURAL ANALYSIS) AND A LANDSCAPE INFORMATION (DERIVED FROM DEM)

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Among soil analyses at the landscape scale, the "structural analysis technique" defined by Boulet and al. (1982, a, b, c) is actually widely used. Its principle is to examine, in detail, the soil mantle of entire slopes using punctual observations (auger hole and/or soil profile) for the identification of pedological systems. The profile observations are performed along a transect in regular intervals followed by additional observations due to the soil variations. To map the whole research area, the different soil layers (Soil Science horizons) are identified through the soil scientist using an expert interpolation between different transects. For the investigation of larger areas (several hundreds of thousand hectares), this technique encounters methodological and economic difficulties: first, only punctual observations are empirical available, and second, the process turns out be very costly due to the large number of data required. Additional techniques of the field of soil cartography are necessary. Among these, soil predicting models using terrain attributes derived from digital elevation models (DEM) can be used. Two examples (one in tropical climate, located on sandstone's of Bauru in Southern Brasil, the other in an oceanic climate, located in an acid rock area with loamy soil in the Armorican massif in Western France) demonstrate how the "structural analysis techniques" completed with models, relating the soil organization to the variation of terrain attributes highly improved soil cartography on large areas.

Words keys: soil cartography, structural analysis, soil landscape models, tropical and oceanic climate.

GEOMORPHOLOGY AND DARK SUPERFICIAL HORIZONS IN A SMALL WATERSHED IN "SERRA DO MAR" (PETRÓPOLIS - RIO DE JANEIRO STATE - BRAZIL)

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This research aims to characterize the geomorphological aspects of the areas where dark superficial horizons occur in relation to mountainous region. These kind of horizons present high organic matter contents and according to the Brazilian Soil Classification System they are called "humic" and "proeminent" A horizons since they have low base saturation values ($V < 50\%$). For this, a small watershed with about 10 Km² - Manga Larga river basin - was chosen in Petropolis municipality, in Rio de Janeiro State. The locals of the soils with dark A horizon identified during the fieldwork were assigned in topographic map and aerial photographs. Laboratory analyses have shown that the organic matter contents reach 11,06%, decreasing with depth, that can be 1,60 meters. The basin present a great altitudinal variation, from 700 to 1400 meters with a very steeply sloping relief, being 20 to 45% the slope category dominant. There are rock walls that outline the local lithology composed by granites and granodiorite gneiss. The hipsometric, slope gradient and geomorphological features maps elaborated for this area show that the "humic" and "proeminent" horizons can be found since 800 meters of altitude in moderately steeply sloping relief (8 to 20% slope category) and in concave morphologic features (hollows), normally with an apparent slope rupture, being the upperslope lightly steeper than the downslope. The results point out that, in spite of the rainy tropical climate, it is possible to find these specific types of horizons if there is a set of favorable conditions to the organic matter accumulation.

GENESIS OF HUMIC OXISOLS AND ITS RELATIONSHIP WITH THE EVOLUTION OF THE LANDSCAPE OF A CRATONIC AREA IN THE SOUTH OF MINAS GERAIS STATE, BRAZIL

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A study on the genesis of humic Oxisols and its relationship with the evolution of the landscape was carried out in an area of 5,750 ha situated in the central segment of the South of Minas Gerais State. Two morphopedological systems (SMI and SMII), representative of the regional geology and geomorphology were chosen. Pedological (chemical, physical, morphological, micromorphological) and geomorphological studies, as well as soil charcoal quantification and radiocarbon dating were performed in four profiles classified as: Humic Xantic Hapludox and Typic Hapludox in SMI, and Humic Rhodic Hapludox and Rhodic Hapludox in SMII. The strongly developed umbric epipedons of the humic Oxisols are thought to be very old and have a continuous, progressive melanization with depth, probably deeply affected by charcoal fragments decomposition and its redistribution by soil fauna. Charcoal is more abundant in these oxisols than in others found elsewhere in the landscape. In situ soil formation in SMII suggest a great stability of the plateau where humic Oxisols are found.

This also suggest higher incidence of fires at this landscape position during the Quaternary, which can explain the higher soil charcoal content in the humic Oxisols. The occurrence of this kind of soils on the lower backslope and footslope of SMI indicate an important short-distance soil transport, probably as a consequence of substratum block tilting during Quaternary times. Fault mirrors in the saprolite and in the solum of one Oxisol, dramatic differences among charcoal datings between 125 and 150 cm of depth (from 6,850 to 40,000 years BP), as well as the seismic disturbances occurring at present in the area point to the role of resurgent tectonics in the evolution of the landscape. Thus, the humic Oxisols could be considered as relic paleosols and, as such, they would constitute a fundamental link to understand the dynamics of regional landscape.

RELIEF, SURFACE DYNAMICS, AND SOILS OF THE SERRA DO MAR (UBATUBA, SAO PAULO)

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Soils, relief, surface dynamics, and their interrelations were investigated in the scarps of the itamambuca basin (Ubatuba, SP). The study area lies within a state park and the forest cover -the vanishing Atlantic Forest- is mostly primary.

The region has an af - cfa climate type with a marked maritime influence and high atmospheric humidity and rainfall rates. precambrian basement is composed of partially migmatized charnockites; quaternary sediments are continental (e.g. talus slopes, alluvial fans) and/or marine.

We have recognized four distinct units:

1. superior slopes. erosive and straight steep slopes ($>30^\circ$). main surface processes are creep, landslides, subsurface runoff, and infiltration due to the high density of the forest. despite the steepness, soils are deep and highly weathered, mainly typic hapludox (lva), clayey, allic, kaolinitic, with low silt:clay ratios (<0.2) and ki indices (<0.6).
2. intermediate slopes. straight slopes (20° - 30°), where detrital material may occasionally accumulate. creep and the other processes mentioned are also the determinants of surface dynamics. similarly, the main soil type is the typic hapludox;
3. colluvial deposits. accumulative slopes (5° - 20°) convex in profile, reworked at the base by river action and also affected by creep, landslides, and subsurface runoff. soils are mainly oxic dystropepts (ca latossólico). the low ki index (0.33) indicates a pre-weathered parent material;
4. alluvial-colluvial deposits (alveoli) and alluvial fans ($<5^\circ$). fluvial erosion and deposition, and runoff are the main surface processes. soil may be fairly developed in the alveoli, where lithic oxic dystropepts (ca) predominate. Tropofluvents (aa) occur in restricted portions of the alluvial fans; on most of these deposits there is no soil cover.

The presence of deep and highly weathered soils on the scarps of the serra do mar confirm that the only appropriate "use" for these unstable area is the effective preservation of the primary forest.

HOLOCENE AND PLEISTOCENE PALEOSOLS AND POST-EUROPEAN COLONIZATION EROSIONAL DEPOSITS IN THE SERRA DE SÃO JOSÉ (MINAS GERAIS BRAZIL)

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After a detailed soil survey on the summit of the Serra de São José (Minas Gerais State, SE Brasil), two soil profiles (p1 and p2), with alternating sequences of white sand and sandy layers enriched with organic matter on meta-sandstones of the Tiradentes formation, were characterized. The study site is located at 1450 m above sea level and 300 m over the dominant regional topographic level. p1 is located 50 m apart from p2 and 1.5 m higher in elevation. In P1, 33 organic-rich layers with a plane-parallel stratification and widths varying between 1 to 60 mm down to the rock contact, were identified. In P2 the organic-rich layers are wider (between 10 and 130 mm) and presented abrupt discontinuities probably due to low impact tectonic movements. Three layers selected from P1 (20-30, 70-80 and 100-110cm) have a C content of 0.5, 7 and 1%, and radiocarbon ages of <40 , 180 ± 60 and 350 ± 80 BP, respectively. These ^{14}C dating indicate the existence of a recurrent depositional process with increasing intensity up to present, coinciding the age of the deeper layers with the beginning of the post-european colonization period. During this period erosive processes were probably triggered by human activities. In P2, the organic-rich layers buried between 20-30, 80-90 110-120 and 170-180cm have a C content of 3, 2.5, 21 and 1.5% and radiocarbon ages of 3580 ± 80 , 3750 ± 80 , 21210 ± 180 and 24060 ± 130 BP, respectively. The C/N ratios of the organic-rich layers showed an increase from the most recent (around 20) to the oldest (maximum around 100) layers. The lack of continuity between both profiles can also be associated to resurgent tectonic phenomena. The drainage in P2 is impeded in the deeper layers, which could be the cause for the preservation of a wood fragment (5cm diameter and 62cm on length) at a depth of 200cm with an age of 32220 ± 290 BP. The soils characteristics and the ages found are promising to continue studying the relations between paleosols, paleo-climates, paleo-vegetation, resurgent tectonics and anthropic action on the evolution of the local landscape.

Abstracts **delivered at IAG 1999 Regional Conference on** **Geomorphology**

SESSION: Hillslope Geomorphology **(Symposium on Gully Erosion & Symposium on Slope Processes that Produce Stone-Lines)**

1. THE USE OF GROUND PENETRATING RADAR (GPR) TO ACCESS SUBSURFACE STRUCTURES NEAR A HOLLOW WITH GULLY, GOUVEIA - MINAS GERAIS
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SYMPOSIUM: SLOPE PROCESSES THAT PRODUCE STONE-LINES

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THE USE OF GROUND PENETRATING RADAR (GPR) TO ACCESS SUBSURFACE STRUCTURES NEAR A HOLLOW WITH GULLY, GOUVEIA - MINAS GERAIS

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Hollows are common features of the landscape in the studied area. In some of them the presence of gullies was detected. To know the subsurface structure of the slope where they occur may enable a better understanding of gully development. The sampled hollow occurs on the granite complex of the crystalline basement of Gouveia in an area marked by tectonic contact with schist, showing also the presence of granite and schist millonites. In the lower part of the hollow gully process had been taking place regardless of a dense vegetation cover of grass and shrubs. The hollow was surveyed with GPR (Ramac) with 50 MHz and 100 MHz antennas. The GPR emits EM-pulse wave down to the ground by the transmitter antenna. The wave reaches the target, refracting and reflecting back to the surface where the receiver antenna receives it. The refraction and reflection are constrained by the contrast of dielectric properties between the soils/rocks discontinuities (dielectric impedance). The time-section conversion to depth-section is done using the velocity obtained by the CMP (common mid point) survey. The GPR profiles were carried out in both directions, perpendicular and parallel to the main direction of gully drainage, which is almost N-S. The perpendicular profile was obtained on the left border of the hollow; the others were perpendicular to the gully drainage direction using both antennas: one next to the gully head and the other at the hollow mound. The CMP's profile was obtained at each initial profile point. The data was processed using standard procedures: declipping, filtering, gains, and migration. Geomorphological, geological and pedological profiles information from the area was added to allow the interpretation of these sections. Some structural features were identified: fractured zone and its (apparent) direction, quartz veins, geologic contact, water table, soil/rock contact.

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TROPICAL LANDSCAPE EVOLUTION: WEATHERING AND EROSION PROCESSES IN GOUVEIA, MINAS GERAIS, BRAZIL.

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There has been a growing awareness of the importance of the weathered mantle in tropical landform evolution. In Gouveia geochemical characteristics and thickness of the weathered mantle have a close association with lithology, inherited landscape and erosional phases that has been taking place on a former erosion surface. This surface was elaborated on the granit-gnaiss from the crystalline basement and schist from the Supergroup Rio Paraúna. It has been reshaped, in a first phase, through the opening of the main drainage, accompanying broad geological features such as anticlinal axis and transforming fault systems, while the secondary drainage system had made its incision preferentially along basic and metabasic intrusions. Drainage incision has created lateral gradients that in some places presented headwater retreat. The retreat, characterising the second evolutionary phase of local relief has shaped amphitheatres and hollows that sometimes show the presence of "rampas de colúvio". This phase has been taking place at least since the upper Pleistocene (corresponding approximately to the Laschamps subchron) leaving humid-clays, with until 23% of organic matter, as correlative deposits. They were dated with C^{14} ($\delta^{13}C$) and the results vary from $38,750 \pm 5,100/3,100$ Yrs. b.p. to 215 ± 150 Yrs. b.p. showing different periods of erosion/deposition cycles. X-ray analysis of clays shows the dominance of gibbsite and kaolinite in soils of the remaining older surface that still covers the tops of slopes. These soils present also high values of Al and Fe and very low Ca, Mg, P, K and N contents. The most recent phase is marked by gully incision. The reworking of the older surface has created conditions for a younger soil to develop with better edaphic conditions. Clays of 2:1 type are dominant in these soils that have also higher macronutrient content and were formed on the valley side, amphitheatres and hollows. The opening of lateral gradients has played an important role in increasing down-slope washing of clay and organic matter, propitiating accumulation on the lower slope, transforming these soils into better ones, capable of sustaining dense and rich vegetation cover, and intensive agricultural use.

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GEOMORPHOLOGY AND SOILS IN THE UPPER JEQUITINHONHA BASIN HIGHLANDS

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The relationship between soils and geomorphology was analyzed in the upper basin of Jequitinhonha River, through study of five soils profiles: a weakly developed Latosol originated on metabasic rocks (near Serro), a Red-Yellow Latosol developed on Tertiary sediments (region of Guinda-São João da Chapada) and a catena composed by a Red-Yellow Latosol, a Quartzic Sands and a Podzol and developed on quartzites and sandy sediments. The soils represent yet the main rock types of the Diamantina-Datas-Gouveia Plateau, which corresponds to the Upper Jequitinhonha basin highlands.

The variety of rock types, associated to the diversity of geomorphological features occurring in this region permitted the coexistence of very different pedosystems. In fact, the region shows side by side sandy and clayed soils, with chemical, physics and mineralogical characteristics partly inherited from parental lithologies, partly associated to the long landscape history, sometimes rejuvenated by the morphogenesis, other times deepened by the pedogenesis.

The first results reveal that the catena Latosol-Quartzic Sands-Podzol represents a hydrosquence with progressive ferrolysis towards the lower part of the landscape, as observed in hydrosquences models presented by other authors.

The sequence is progressively hydromorphic, where the destruction of the plasm took place in acid environment.

The latosol of the highest landscapes developed from allochthonous clayed-sandy sediments, settled in disconformity on the quartzites and its weathered products, and it doesn't show evidence of ferrolysis.

The origin of allochthonous latosolic covers can be the sediments originated from mafic intrusions that cross-cut the quartzitic plateau, where the selective erosion has affected them at deeper levels than the quartzitic crests. Thus, it seems evident that a recent relief inversion took place. Its consequence is represented by the higher position of those flattened remnants, ancient playas or wide pediments, between quartzitic monadnocks.

CONTRIBUTION OF PEDOGEOCHEMISTRY TO THE ANALYSIS OF LATERITES RECOVERING EROSIONAL SURFACES AT THE EAST BORDER OF SAO FRANCISCO KRATON- MINAS GERAIS - BRAZIL

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Levelling surfaces as a result of geomorphic processes acting in the past has been a very usual geomorphic interpretation for landscape of some areas. There were identified five standard types of laterites located at the east border of the São Francisco Craton. They were grouped in accordance with their morphological characteristics that show a correlation with their probable genesis and with some geologic and geomorphic aspects related to their development. The sampled areas are representative of an extensive planation surface occurring in the Serra do Cabral and Água Fria. Sometimes these laterites are associated with the presence of massive deposits of well rounded pebbles of fluvial origin, possibly Cretaceous, occurring between 800 and 950m height, well above the base level of nowadays drainage. In this research the evolution of lateritic profiles was analysed based on pedogeochemical aspects that could be associated with the profile genesis. Emphasis was placed on the degree of weathering and on the chemical characteristics of the material, in order to establish possible chronologies for the elaboration of the levelling surfaces. Analysis of some of the lateritic profile constituents (Fe_2O_3 , Al_2O_3 , SiO_2 , TiO_2 and P_2O_5), show certain homogeneity in the values of all chemical elements, except TiO_2 that occurs with values varying from 3,00 to 4,00 in 3 of the 10 studied profiles. These different values suggest the existence of a relationship between the high values found for TiO_2 with the type of rock underlying the profiles. This has been also detected by others researchers, indicating genetic association between laterite types and local geological diversity. In studies of several laterites over the world high ratios of TiO_2 , which is found in basic rocks, were observed. This lithology coincides with those presenting high values of TiO_2 occurring in the study area. The alteration degree of the ten profiles, on the basis of their chemical characteristics, allowed to identify the following chronological sequences: a younger surface, with K_i index values ranging from 2,07 to 2,12; an older one, with K_i index around 1,59; and a third surface with very low K_i index values (0,64) indicating the existence of a larger amount of free aluminium (gibbsite), contrasting with the amount of kaolinita which is dominant in the other profiles.

*This research was financially supported by FAPEMIG.

GEOMORPHOLOGY OF THE TIJUCA MASSIF, RIO DE JANEIRO: PROCESS-RESPONSES TO EXTREME RAINFALL EVENTS

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A Tertiary normal faulting system gave rise to the coastal ranges of Rio de Janeiro where Precambrian gneiss and granite rocks prevail. Geological structures favor the in situ origin of rounded boulders and blocs. Conspicuous morphological features are given by round-shaped rocky peaks, called "sugar loaf", and long-steep rock escarpments (>50°) operate as water recharge zones. Block-rich slope deposits (talus and colluvium) are relatively thicker at the foot of rock-escarpments or along gentle inclined valley bottoms.

In the Tijuca massif a late secondary Atlantic rainforest yet prevail despite the strong urban pressure in the surrounding area; however forest degradation is accelerated onto steep slopes due to urban interferences. Two extreme rainfall events were recorded in the last 30 years in the Upper Tijuca massif (Tijuca National Park): one in February 1988 reached 260mm in the critical day; another in February 1996 when rainfall intensity attained 380 mm in less than 24 hours.

The 1988 event (Guidicini-Iwasa coeff. of type B) led to sparse landslides in the steep slopes of the National Park and surrounds, being more concentrated along the road cuts. In the 1996 event (Guidicini-Iwasa coeff. of type A, or extreme landslide hazard), several landslides spread simultaneously onto the steeper western slopes of Papagaio peak, being relatively sparser in the eastern slopes which drain toward the National Park. Initiation was probably related to mass impact or suddenly increase of pore-pressure; debris flows predominated and few shallow failures occurred. The downward propagation was strongly influenced by topography and forest degradation. The eastern-landslides occurred within the National Park and did not propagated far away apart from their initial places: coarse debris load (blocs, soil and trees) remained stored in minor hanging plateaus. The longer and steeper western slopes were largely affected by landslides and extensive rock debris avalanches (>4 km length) reached the adjacent baixada of Jacarepaguá. Avalanches led to bedrock incision, leaving behind deeper and wider channels.

CUESTA -TYPE LANDFORMS IN THE SOUTH AMERICAN SUBHUMID TROPICS - A CASE STUDY

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Detailed geomorphologic survey was carried out on a cuesta escarpment section within the border of Parana sedimentary basin aiming to propose an explanatory description of those landforms. Together with data concerning chemical weathering, biological processes, present-day morphogenesis, and tectonics this research intends to contribute to the better understanding of geomorphologic evolution on cuesta-type inter-plateaux transitions in South American subhumid tropics.

Landforms analysis was performed between the cities of São Jerônimo da Serra and Sapopema (Paraná state). Within the sedimentary basin flood basalts built by Jurassic fissure volcanism alternate with Palaeozoic-Mesozoic sedimentary rocks; altitudes range from 200 to 1200m a.s.l. The sample section encloses from top to bottom the back-slope known locally as "third (highest) plateau", the front slope or cuesta escarpment, and the associated orthoclinal lowland. Slope profile survey employed Pitty pantometer which allows direct data survey of slope profiles with a 1.5m accuracy. Numerical analysis followed Doornkamp & King (1971) and Blong (1975) procedures and led to the development of techniques for automatic identification of inflection points, i. e., points limiting segments and elements in the slope profile. Correlation of field survey results with contour maps and GPS (Global Position Satellite) data besides the use of infra-red interaction engineer level made the building of contour maps and surface diagram blocks possible.

PLANATION SURFACES IN SOUTHEASTERN BRAZIL: SAO JOSÉ DOS CAMPOS PLATEAU (TAUBATÉ BASIN, SAO PAULO)

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The study area comprises a stretch of hilly landforms on the right margin of the Paraíba do Sul river, approximately between São José dos Campos and Caçapava cities, known as São José dos Campos plateau. The Paraíba do Sul river upper-middle valley is located in Taubaté basin, a 220 km long continental taphrogenic basin in the E-NE trending Serra do Mar Rifts System, filled with Tertiary and Quaternary sediments of Taubaté group. The middle and upper fluvial - lacustrine rock sequences include mudrocks and claystones interbedded with, and capped by, sandstones and pebble layers.

Multispectral MSS/LANDSAT images helped to identify topographic levels and interfluvial morphology in the SW section of Taubaté basin. Level summits (630 to 700 m) located along the NW slope of Serra do Mar are the best preserved areas of a Upper Tertiary planation surface identified as Neogene by Martonne and currently known as São José dos Campos plateau. Narrower and lower (610 to 630 m) interfluvial areas are found downstream.

Detailed landform and materials survey indicate the regional extension of depressions and slope hollows and predominance of extensive latossolic covers which can be related to geochemical activity in São José dos Campos surface. Progressive lowering of interfluvial areas from SW to NE points to ongoing degradation of the planation surface from Caçapava towards the SW extremity of Taubaté basin. These processes are probably linked to water-table lowering to a regional base-level associated to exposures of Precambrian rocks cutting Tertiary sediments near Caçapava. Predominance of solution processes reveal that São José dos Campos plateau evolution is related to geochemical processes and etchplanation rather than to mechanical morphogenesis as previously suggested.

GEOTECHNOLOGICAL ANALYSIS OF GULLY PROCESSES OF GOUVEIA - MG

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This paper presents the results of a research conducted in Gouveia with the objective of characterizing the phenomenology of gully processes under the geotechnical point of view. It emphasizes the influence of different materials related with the dynamics of the mass movements involved in the regressive retreat of gully head. The study area is localized at approximately 8 km of the city of Gouveia on the slopes limited by Padre and Tamanduá streams. On these slopes there were 11 gullies observed, 8 of which are active. The gully process in this area shows an intimate relationship with the local geology and with the anthropical activity which has been taking place in that area over the decades. The influence of geology in the gully evolution begins when planes of rock weakness (foliation, fractures, etc.) are intercepted by channel incision in the initial stages of erosion. Both regressive headwater erosion and lateral enlargement transversal to the gully axis are conditioned by the direction and dip of structural rock features. Also the different resistance to the erosion is imposed by different rock lithology, being the diabase the most prone one in comparison to the schist and granit-gnaiss. When the depth of the erosion reaches the phreatic level, the process is abruptly increased with development of piping, digging out the foot of the gullywall and collapse of blocks of the saprolite leaving verticals high walls. The results of the hydrogeotechnical analysis, including discharge measurements, allow the following conclusion: the stream flow average inside the sampled gullies reached its maximum 7 months after the beginning of the rainy period. During May the stream flow is 10 to 15 times bigger than that measured in October, period of the beginning of the rain; the role of piping in the headwater regression is more accentuated in those gullies situated at the upper streams basin.

*This research was financially supported by FAPEMIG.

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FEBRUARY 1996 LANDSLIDE SCARS AND SUBSEQUENT EROSION: TIJUCA MASSIF, RIO DE JANEIRO

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In response to extreme rainfall events of February 1996 (380 mm, less than 24 hours) landslide scars spread along the western peak zone of Tijuca massif, between Papagaio and Taquara peaks. Debris flows and shallow failures left behind finger-like scars before feeding extensive rock debris avalanches along the main river channels which drain toward the baixada of Jacarepaguá. Finger-scars (n= 93) vary in size, shape and surface materials (bare rocks, weathered rocks, saprolite or colluvium). An erosive feature prevail on steeper slopes, while a depositional zone may be developed in the lower portion, particularly when associated with slope breaks at hanging plateaus or adjacent valley bottoms. Erosion is dominated by the action of hortonian overland flow. Gullyng tend to develop onto the depositional zone and may extend over the upper erosive zone wherever soil is available for transportation. Rocky blocks remain as lag deposits into the gully, particularly in the plateaus and valley bottoms filled up with landslide deposits.

Detailed field observations and erosion measurements have been conducted in a representative landslide scar of February 1996, which is located in forested-slopes in the eastern side of Papagaio peak. The average sheetwash erosion is on the order of 10,5 ton/ha/year; ranging from 30 ton/ha/year, on bare soil to -0,056- ton/m²/year on the interrill vegetation regrowing area. In the depositional feature, the average gully erosion rates (measured for the period of august 1997 to april 1999) is on the order of 4.450 ton/m²/year.

Erosion susceptibility and rates will tend to increase around the scar, as landslide-clearing sites promote forest deterioration and decay of root strength due to border effects (microclimatic changes), especially in larger scars. In ten years forest vegetation will not be fully recovered in their functional aspects that regulate both hydrological and mechanical soil properties on forested slopes.

THE ROLE OF MESOFAUNA ON THE RECYCLING OF THE SOILS ON THE SLOPES AT GOUVEIA, MINAS GERAIS

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The influence of the fauna on the development of slope processes has not yet received sufficient attention in geomorphologic studies. Preliminary studies in the area have detected the intense activity of meso-fauna (termites and ants) providing the slope surface with a representative amount of loose material washed down-slope by sheet erosion. This study has focussed the attention onto the impact of the meso-fauna on the physic and chemical characteristics of the soil. They are predominantly latosoils developed on granit-gnaiss of the crystalline basement, and of schist from the Rio Paraíba Supergroup, in Gouveia, MG. They are very weathered soils containing low concentration of Ca, Mg, K, P, N and high of Al and Fe. Thirty geomorphologic sites were identified in ten slopes, along the Chiqueiro Basin, in the middle of which soil profiles were opened, observed and sampled for laboratory analysis. Within 40m around the site, measurement of termites and ants mounding as well as samples for laboratory were taken. Results of chemical soil-analysis have shown a higher concentration of macronutrients in the superficial horizon of the soils localised near the mounds compared to those located at greater distances. Although similar results are reported in the literature, the values are not as representative as those found for Gouveia. This is very important to enhance soil capability of sustaining vegetation cover and soil resistance to erosion. The X-ray analysis of clay demonstrated that the mesofauna proceeds to a selection of the edaphic material to build the mounds, especially the termites that use more 2:1 type of clays. In doing so they have an important role in recycling the soil of the region.

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HILLSLOPE EVOLUTION BY DIFFUSIVE PROCESSES IN SOUTHEASTERN BRAZIL: THE CONVEX HILLTOPS OF MAGÉ (RIO DE JANEIRO)

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Soil-mantled landscapes, like the "Mar de Morros" of southeastern Brazil, are characterized by smooth convex hilltops. These forms have been interpreted as characteristic of well-developed landscapes, as the ones prevailing in most of the tropics nowadays. They have also been used to support the classical idea of dynamic equilibrium, implicitly proposed by Gilbert and later extended by Hack.

Although the origin of these convex hillslopes have been attributed to the work of diffusive (slope-dependent) processes like creep, rainsplash and biogenic activity, numerical models have shown that baselevel changes, controlled by the incision rate at the base of the profile, also play a major role on controlling the final hillslope curvature. Besides, it is known that equilibrium profiles may be attained on hillslopes evolving, under constant diffusive processes and incision rates (B_d), for a period of time longer than the hillslope relaxation time. However, some of these numerical experiments suggested that the relaxation times for these convex hilltops, when responding to the typical climatic and tectonic oscillations that have occurred along the Quaternary, may be much longer than the frequency of such oscillations, prevailing these hillslope profiles to attain the dynamic equilibrium condition. Although the diffusion coefficient (D) is a key parameter in diffusion-based models of landscape evolution, few studies have tried to estimate it from field investigations.

This study focuses on the geomorphological meaning of the smooth convex hilltops of Magé, Rio de Janeiro, based on field investigations and numerical experiments. Detailed curvature profiles were surveyed on many hillslopes and the ratio B_d/D was later estimated. The results showed that this ratio varies inside a small range, from 25 to 130 ($\times 10^{-4} \text{ m}^{-1}$). Because the incision rate and the diffusion coefficient may vary a couple of orders of magnitude, the results presented here do not allow us to neglect the idea of dynamic equilibrium in this area.

IRON OXIDES EFFECT ON FINE PARTICLES AGGREGATION: IMPORTANCE FOR SLOPES HYDROLOGY OF TROPICAL SOILS

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Agglutination of clay particles in tropical soils is not well studied although it is already known process in the savannah conditions. This research had the objective to verify clay behaviour in the savannah latosols from Gouveia and also to detect possible causes of it. The B-horizon of soil collected on the upper slopes, and developed over three different lithologies: schist, granite and metabasic rocks, was analysed. Two granulometric analyses were conducted: with NaOH and H₂O. Silt particle was treated with DCB, DRX, Mössbauer spectrometry and MEV to determine physical and chemical differences between the types of soil from the three lithopedological domains. The results of the texture using two different dispersants show great variation. There is a significant increase in the percentage of clay after the treatment with NaOH, indicating the occurrence of aggregation of this particular size that is not detected when only H₂O is used as dispersant. The most representative variation of the percentage of clay is that of soil from metabasic rocks, richer in iron content. Treatment with DCB, which takes away crystalline iron oxides, shows even more expressive results with the increase of clay in detriment especially of silt percentages, although percentage of fine sand has also shown decrease. X-ray diffractometry of the samples demonstrated the predominance of aluminosilicates minerals. The EM detected the presence of goethite and hematite in all soil samples, and of maghemite in those of metabasic rocks. The results of the MEV show a hierarchization in the aggregates micromorphology. These macroaggregates as well as the voids size are bigger in the soils from schist. In contrast, in the soils from metabasics the aggregates and the voids are smaller and less frequent. Soils from granite show intermediated characteristics of both previous ones. The results draw the attention to the agglutination capacity of iron oxide, although aluminium and silica can also be involved. A better understanding of this process in tropical environments is of fundamental importance because of its influence on hydrological behaviour of soils.

*This research was financially supported by FAPEMIG.

STUDY OF THE EVOLUTION OF A SLOPE BASED ON THE ORGANIZATION OF THE PEDOLOGIC COVERING, JAGUARIÚNA (SÃO PAULO) BRAZIL

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The present study was conducted in the county of Jaguariúna (Experimental Field of the Embrapa, Environment), to understand the recent evolution of the slope adjacent to headwaters. A representative soil transect was studied through borehole and trenches, of the top up to the drainage axis, with the objective of reconstituting of the organization of the pedologic covering. It was verified that, starting from the inferior third part of the slope, it exists, inside of the latossolic covering, a hidromorphic horizon. This horizon has the same morphology of the current water magazine located in the base of the pedologic covering. These two hidromorfs groups are separated through a latossolic material that disappears when these two groups reach each other. In the basis of the slope, above the alteration material with facies of water magazine, there is a peat, with up to 1,5m of thickness, dated, through 14C, of 31250 + / - 250 years AP. Covering it there is a colluvium.

We have hypothesized that the horizon with morphology of water magazine constitutes a relic of an old magazine from a period when the pedologic covering was in higher level than the current. The understanding of the several phases of evolution will distinguish the following episodes in the considered period (of unknown maximum age):

1. - An initial phase in that a latossolic covering existed with suspended water table,
2. - An incision phase due to a fast lowering of the base level,
3. - A phase of stability of the base level when the drainage axis presented a wetland morphology in which was formed the peat.
4. - The current phase when the slope was rectified by erosion to amount and colluvial deposits at the downstream. The valley acquires morphology in open V, with slopes lightly convex-concave.

THE ROLE OF ROOTS IN THE RECHARGE AND DRAINAGE OF FOREST SOILS

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Studies seeking the understanding of the role played by the root systems in the recharge and drainage of forest soils, were developed in a sub-basin (Snake Catchment), in the Tijuca Forest National Park, Rio de Janeiro. Tensiometers were installed in areas with and without the presence of roots of arbore affixation. Along one year, daily readings were accomplished and, during the rains, in smaller intervals of time. It also took place the characterization of the vegetation structure, of the roots distribution biomass and analysis of the physical and hydraulic properties of the soil matrix.

The results demonstrate that the depths of 10 and 20 cm present the largest monthly medium suctions along of the year and the layer of 40 cm presents smaller suctions than the layer above it. The depths of 80 and 120 cm present the smallest suctions, with low variations along the monitorated time. During the rain events, the tensiometers around the trees present smaller suctions than the area without the presence of roots, which demonstrates a faster recharge in these areas. Shortly after the rainfall, the depth of 40 cm drains more rapidly. The most superficial layer wets and drains quickly, being this behavior related to the physical properties of the soil and the biomass of fine roots. In the subsurface layers, the recharge and drainage processes in the areas with presence of roots happen in a faster way, attesting the role played by the root systems as preferential infiltration pathways.

MORPHOPEDOLOGICAL STUDY OF THE INTERFLUVE BETWEEN SAMAMBAIA AND ARAQUÁ RIVERS IN SÃO PEDRO, SÃO PAULO STATE, BRAZIL

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The main goal of this research was to elaborate a morphopedological map of the northern-central sector of the Araquá - Samambaia interfluve, in São Pedro. We also tried to correlate this map with data extracted from similar studies performed in neighboring interfluves, where three zones with different drainage density and related pedologic systems were identified: Broad Interfluves Zone, Transition Zone and Narrow Interfluves Zone (1:50.000).

Morphopedological compartmentation, based on hypsometric, gradient, morphological and pedological maps, allowed the recognition of seven compartments in the study area (1:25.000) and the comparison with the zones identified in neighboring interfluves.

One of the morphopedological compartments presents the highest altitudes (510 - 640 metres), the lowest gradients (0 - 6°), the lowest drainage density (2.6 Km/Km²) and the deepest soils along hillslopes in the study area and can be compared with Broad Interfluves Zone of the adjacent interfluves; two of them present lower altitudes (470 - 608 metres), higher gradients (6° - 20°), higher drainage density (4.0 - 4.3 Km/Km²), thick soils on the tops and shallow soils on hillslopes, corresponding to the Narrow Interfluves Zone outside the sample area; and two compartments present intermediate features of the previous ones, similar to the Transition Zone identified in the neighboring areas.

The two remaining morphopedological compartments show low to high gradients (0 - 20°), medium to high drainage density (3.9 - 7.5 Km./Km²) and predominance of shallow to medium-thickness soils. Similar features were not found on interfluves outside the area.

INTEGRATED STUDY OF LANDFORM MORPHOLOGY, SURFACE MATERIALS AND CURRENT EROSION DYNAMIC IN THE ANALYSIS OF THE GEOMORPHIC SYSTEM

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This study aims the interpretation of geomorphic system, starting from the comprehension of the spatial arrangement of the landform morphology, the unconsolidated superficial materials (elluvium, colluvium, alluvium) and current geomorphic/hydrodynamics process, supported in Ab'Saber's (1969) conceptual proposition, and according to the interpretation of system in Geomorphology presented by Carson e Kirkby (1972).

The area core ("Mestre Álvaro", Serra/Espírito Santo/Brazil) is a semicircular geomorphologic unity presenting an intrusive structure, a granite body, gneiss in the boards, with topographic amplitude above 800 metres, near the coast, with an annual average precipitation of 1.300 mm; presenting orographic effect upon the air mass, which produces a great pluviometric gradient that reaches the surface of the hillslopes at unbalanced concentration in the different faces of orientation, characteristic of a possible influence upon the dynamic of evolution of geomorphic processes.

The arised hypothesis is the one which shows the existence of observable differentiation in the characteristics presented by the superficial materials in different altitudinal positions and orientation of hillslopes, corresponding to the elements presenting 4th, 5th e 6th taxonomic order forms defined by Ross (1992), respectively, topomorphological areas all over the mountain, hillslope morphologies and the geomorphic/hydrodynamic processes.

Therefore, the study finds fundament in two main methodological propositions for the execution of an analysis related to the Geomorphology:

1. Application of Minimum Feature Model (Colangelo, 1989) in the cartographation of integrated forms, materials and processes, which assuring the immediate visualization of the relationships established between the variables, besides the respective measurements.
2. Use of semilogarithmic analysis of magnitude-frequency of the daily rainfall (Ahnert, 1987) in the identification and study of "the most effective" event and associated processes.

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THE GEOMORPHOLOGICAL EVOLUTION OF THE NAMIB DESERT

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The Namib Desert in south western Africa, has a long history of evolution. In the Cretaceous the opening of the South Atlantic and the presence of a mantle plume led to the emplacement of various major intrusions and the eruption of great spreads of lava - the Etendeka lavas. The present landscape of the Namib shows the impression of these events. In addition, there is evidence that aridity has characterised the area for much of the last 140 million years, and that processes such as salt weathering have led to the planation of extensive areas. The Namib is dominated by the major intrusions, by wide plains, and by a Great Escarpment.

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PARAMETERIZATION OF A MODEL FOR THE TOPOGRAPHIC CONTROL ON SHALLOW LANDSLIDING FOR APPLICATION TO RIO DE JANEIRO, BRAZIL

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A key problem in the use of physically-based models of landslide hazards is how to parameterize the representation of soil properties. We applied a physically-based model for the topographic control on shallow landsliding (SHALSTAB) to two catchments in Rio de Janeiro. In particular we investigate the accuracy of the model results in relation to parameterization of soil properties to address the relevance of the use values derived from laboratories tests to the field problem and the trade-offs inherent in model parameterization when such data doesn't exist. From this previous research we established the relation range of possible cohesion, bulk density and friction angle values and run the model for all of possible discrete combinations. Many comparisons were made between model results and mapped landslides scars. Through the number of the pixels that corresponds to be predicted unstable for each set parameter was built a rank sorted from the best to worse model results performance. To optimize and to better visualize this methodology we submit the data rank to a robust regression, to find an equation that represents all the parameters combinations. With this equation we found a surface that represents the combination of the best parameterization for the best rank results. Our analysis suggested a trade off such that there isn't a unique best model and also showed the importance of to calibrate such model to field data. The results attest that the application of the model to an area where the soil properties are not well known requires a previous calibration of these parameters with the landslide map. Only after this step, the model can be used as a predictive tool.

RELATIONSHIP BETWEEN MORFOMETRIC AND LANDSCAPE ASPECTS OF GOUVEIA, MINAS GERAIS, BRAZIL

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The municipality of Gouveia is part of the Mining Micro-region of Diamantina, localised in the Alto Jequitinhonha Zone, in the so-called "High Surfaces Elaborated on Proterozoic Rocks" domain. The relief is predominantly developed over rocks of the Espinhaço Supergroup where there is also the highest altitude of the municipality (1,582 m). It presents a Cwb (mesotemic of altitude) type of climate, characterised by dry winters and mild and humid summers with an average annual precipitation ranging from 1,400 to 1,800 mm. Geomorphologic, climatic and pedological aspects of the area associated with the type of land use are responsible for the erosional problems along the entire agricultural zone. In this context it is important to carry out a study with the objective of establishing a correlation between elements of the landscape, such as morphology and superficial slope cover, and morphometric parameters. This approach allows a better understanding of local landscape dynamics and the resulting maps can be used as an orientation to land use and occupation. Maps of hydrographic and relief amplitude were produced, digitalised and inserted into digital medium. A cross interaction was accomplished, generating a map of general relief dissection of the area. An orbital satellite TM-Landsat5, RGB453, image was also processed resulting in a superficial formation and land use map. The topographic map has also been digitised in a 3D to enable a better representation of the morphological land use and superficial formation data. All information was inserted in data storage using the softwares MicroStation Geography and MapInfo in order to allow better access, recuperation and future complementation of the data for the study area.

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MORPHOLOGY, ATMOSPHERIC DISCHARGES AND EROSION

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The Espinhaço Range in central-eastern Brazil was chosen by the authors as the study subject for the present research. It represents a typical site for orographic thunderstorms, which develop from the forced ascent of conditionally unstable air along the mountain barrier. Rocks exposed at the earth's surface undergo weathering. The loosening and removal of rock materials by any process, the erosion, is more effective at elevations (e.g. mountain ranges), providing thus the source of debris and resulting in the formation of soils. Atmospheric discharges have very peculiar features: Velocities of 160.000 km/sec and plasma temperatures of 30.000°C are achieved in nanoseconds in lightning channels. The authors introduced the term "Electromechanical-Disintegration" (ED) for damage of minerals and rocks on the earth's surface due to lightning. Evidence are: Presence of b-quartz ($T \geq 573^{\circ}\text{C}$, called "Flashstones" by local diggers); melted barbed wires ($T > 1500^{\circ}\text{C}$); furrows in soils and colluvium up to 100 m long with the presence of cristobalite, the high temperature modification of quartz. (1470-1713°C). In permeable Precambrian quartzites the instantaneous shock rise of temperature from 15 to over 1500°C results in an extremely severe explosion like expansion of water, leading to the formation of fissures and widening of other systems. The enormous pressure of about 35 kbar can be estimated by the presence of coesite relicts, the rare high pressure polymorph of quartz. The ED is one of the more important starting mechanism for other weathering processes, because chemical agents can attack each newly made fragment from all sides and can descend even deeper into bedrock as new cracks are formed or older one extends. Thus, the ED is a new term for a type of weathering as old as the planet's lithosphere and represents an important exogenic process for the beginning of erosion and the formation of soils.

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HILLSLOPE DEPOSITS OF ECONOMIC IMPORTANCE IN THE ESPINHAÇO RANGE (MINAS GERAIS, BRAZIL) THROUGHOUT GEOLOGIC TIME

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Precambrian and Phanerozoic deposits in this Range are locally mineralized in diamond and gemmy quartz, representing the more important surviving mean of its population. The Middle Proterozoic (± 1.7 Ga) diamondiferous conglomerates and alluvial fan deposits are the oldest hillslope deposits of economic importance, and have been worked for over 250 years. The former with a medium minerable ore of 0.01-0.2 ct/m³ have been interpreted as costal deposits, whereas other authors prefer an origin through continental braided systems. The source rock is unknown. The alluvial fans with similar grades are of limited distribution and were formed by mean of steep slopes during a semiarid climate. Two uplifts of the Range generated other hillslope deposits. The first, during the Lower Cretaceous conducted to morphodynamic processes which formed braided river systems. These conglomerates contain locally diamonds from the reworked Precambrian deposits. The second, at the end of Tertiary, shaped the modern Range and resulted in fanglomerates, occasionally minerable for diamonds. Throughout the last glaciation the average annual temperature in the Range was lower than today, leading to frost wedging and to mechanical disintegration of rocks and the more resistant quartz veins. During Early Holocene, about 10 ky BP, climatic changes resulted in a pluvial regime and consequently sheet erosion and the loss of silt and clay on gentle slopes. Colluvial layers have been formed, containing about 80% quartz fragments from the veins in a sandy matrix, locally diamondiferous. Gemmy quartz crystals survived climatic changes and are an easy target for small diggers. The economically more important deposits of the Range are subrecent alluvial gravels. Although of a very low medium minerable content in diamonds, flats have immense reserves. The Espinhaço Range is a typical site for developments of pluriphase hillslope deposits reflecting the economic importance of morphoclimatic processes.

CONCEPTION THE SOLUTION OF PROBLEM OF SURFACE LEVELING OF EPIGEOSYNCLINAL OROGENIC BELTS

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The surface levelling of epigeosynclinal mountains is considered the fragments of abrasion planes formed at the level of common basis of erosion and deformed later on at various levels. The conception of these mountains, the mobile geotectonic systems of lithosphere, complexity the development peculiarities of morphostructures shows not a complete conformation of their penepplanation and transformation at common surface of penephen type. And this, in its turn, is considered as the factor providing the possibilities of incomplete destruction of surface levelling and thus preservation in relief their fragments of Mesozoic age. At the same time, development of morphostructures at the background of sharp differentiated tectonic movements shows the existence between age and height or surface levelling, against traditional accepted one-side correlation (age or surface levelling directly depends on their heights), on many-structured correlation (different age surface levelling are situated closely, same-aged at different levels, young one higher than ancients, etc.). In other hand, genetic adequateness of surface levelling and transgressive disagreement in stratigraphic sections forming the sediments, and space-time relations with each order allow to reveal a certain natural relations between them; surface levelling and disagreement of synchronic phenomena; indices of transgressive and regressive conditions and abrasion of basin and so on. Hence, abrasion-stratigraphical conception is suggested in the solution of the problems of surface levelling of epigeosynclinal orogens, principle of geomorphological correlativity developing as methodological basis of relief studies.

HYDROGEOMORPHOLOGICAL STUDY OF FOUR WATERSHEDS IN THE COASTAL BASIN, PARANÁ STATE, BRAZIL

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Characterized by the presence of the Atlantic Forest, ecotourism, high biodiversity, an environmental protection area and so on, the Coastal Basin is one of 16 Basins in Paraná State, Brazil. In this work, hydrogeomorphological processes were analyzed for 4 watersheds (Nhundiaquara, Marumbi, Tagaça and Guaraqueçaba) in the Coastal Basin. Using maps, the geomorphological characteristics, such as drainage area, coefficient of compactness, form factor, drainage density, steepness and stream order, were determined for each watershed. No significant differences for these factors were found between the four watersheds. Using rainfall and runoff data provided by SUDERHSA, the hydrograph separation in annual water balance was carried out with two methods:

- (1) the graphical method proposed by HEWLETTE & HIBBERT (1967) and
- (2) the numerical model HYCYMODEL. Through the calibration of HYCYMODEL for the rainfall-runoff processes of the watersheds, the values of the 9 parameters of this model were determined.

The results obtained from both methods were almost equal, showing that the baseflow was approximately 29% of the total discharge for Nhundiaquara and Marumbi and 75% for Tagaça and Guaraqueçaba. Parameters D_{16} and D_{50} , expressing the soil layer thickness, were found to be much smaller for Nhundiaquara and Marumbi than for Tagaça and Guaraqueçaba. Therefore it is concluded that a thinner soil layer generates large values of direct runoff in Nhundiaquara and Marumbi and that an opposite phenomenon occurs in Tagaça and Guaraqueçaba.

PRIMARY PRODUCTION OF GRASS LAYER, SOIL VEGETATIONAL COVER FROM A SLOPE IN GOUVEIA, MG: ANALYSIS OF THE EFFECTS OF FIRE

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Extensive cattle raising, one of the main economic activities of the Cerrado area of Gouveia, has been carried out with the use of technique that frequently includes the use of vegetation burning. This study has the objective to verify the effects of burning on the soil vegetation cover and on the biomass production. A catena sequence was sampled and 6 areas, placed in the centre of a geomorphological site, were selected for soil profile observation and for vegetation collection and measurement. Three of these points were localised in places recently burned (less than a week) and three outside the area affected by fire. In each area, four samples of epiphytic phytomass were collected using a 0,25 m² quadrat. To determine soil vegetation cover, the leaf area index (LAI) has been used and the total foliar area per unit of the terrain, obtained through the equipment "Plant Canopy Analyser LI-COR 2000" that gives indirect values of the LAI. An increase of the biomass in the burned areas by the end of the rainy season (April) was observed. The values are ranging from 3.15±0.34 ton/ha to 4.92±0.77 ton/ha in those burned areas, and from 4.42±1.23 ton/ha to 5.00±0.72 ton/ha in those not burned. The values of the LAI have also shown rapid increase after the fire action, reaching after the rainy season values varying between 1,2±0,31 e 2,12±0,2 in those burned, and 1.27± and 2,0±0.55 in those not burned. The results after a year of observation and measurements confirm the rapid recuperation of the grass/herbaceous strata in the geotropical savannas after burning. This has an important influence on soil protection to prevent erosion.

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HYDROLOGICAL DYNAMIC IN THE HILLS OF THE INVERNINHO RIVER BASIN, SANTA CATARINA, BRAZIL

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Mass movements are important geomorphic agents in the Inverninho river basin. Studies carried out in the area showed that hillslope hydrology plays a major role in that movements. Therefore, this study aims to characterize the hydrological dynamic in the hills of the basin.

Toposequences were investigated in a slope limited by the alluvial plain, with height of 50m and with landslide scars. Precipitation, gravimetric moisture and piezometric levels were monitored during one year in this slope.

The material *in situ* along the studied hill forms a vertical succession of horizons following the topography, with lateral variations at the base originated by the water table. Heterogeneous colluvium appears inside the scars and sandy alluvium occurs at the base of the slope. Yellow levels with saturation indication are developed in the materials of the scar, coinciding with the position of the piezometric levels during intensive rainfalls. Also, yellow levels appear in the top of the slope, where they seem to be a stage of shut depressions development. Geophysical investigations accomplished in the area show that the weathered bedrock is deeper at the top of the hillslope than at its base.

An alignment with accumulation of iron is found below the large scar, at the contact of the sandy alluvial package with the weathered bedrock, indicating an old path of preferential flow. Today, subsurface flow converges to an alignment inside the large scar where the topography is divergent at the surface. This occurs because of the existence of colluvial materials with high values of hydraulic conductivity. In another alignment, the concave form of the slope maintains the water table in high total potentials.

The exfiltration of subsurface flow at the footslope expands the scar, generating a channel head with permanent flow. Saturation overland flow was observed in very humid periods in the contact between the hillslope and the plain.

DEEP WEATHERING AND LANDFORMS IN MID- AND HIGH LATITUDES: TROPICAL INHERITANCE OR EQUIFINALITY?

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The last 20 years or so have witnessed a growing number of papers reporting the occurrence of thick mantles of weathering residuals in northern mid- and high latitudes and linking them with landforming processes. In particular, purportedly bare shield areas within the extent of Pleistocene glaciations have been shown to retain an extensive saprolitic mantle whose thickness may well exceed 20 m. Characteristic landform assemblages of residual hills, tors and boulder fields, undulating plateaux and rock-cut basins are interpreted as products of selective deep weathering that has been exploiting various lithological and structural differences within bedrock, hence essentially as an exposed weathering front. The notion 'etchsurface' gains modest popularity and etched landscapes are now described from as diverse areas as Central Europe, the British Isles, Fennoscandian Shield, Iberian Peninsula and Laurentide Shield of North America.

A question arises if the saprolites and associated landforms are relicts of tropical milieu of the Mesozoic and Palaeogene, as has often been claimed, or whether they illustrate the principle of convergence in different morphoclimatic zones. Indeed, it has been demonstrated that many of the thick saprolites and etched landforms are of Cretaceous and/or Palaeogene age, whilst an independent evidence exists for warm and predominantly humid environments at that time. However, it needs to be emphasised that much of the Mesozoic and Palaeogene were protracted periods of tectonic calm, thus additionally favouring weathering profile deepening. The most important finding is the recognition of regionally extensive deep weathering of sandy and *grus* type in the geological record of the rather temperate Neogene. These saprolites, although geochemically 'immature', may attain 10 m or more in thickness and mantle tor-like bedrock projections and boulders. Sandy weathering is likely to proceed at a relatively fast rate and efficient denudation leads to the exposure of a new generation of etchsurfaces that bear no relationship to their much older, 'tropical' counterparts. It may be proposed that tropical conditions are not necessary for the phenomenon of deep weathering to occur and etched landforms to form, although the exact type of weathering, mechanisms of stripping and resultant relief seem to differ between tropical and temperate environments.

PREDICTIVE MODELING OF LANDSLIDING IN SEATTLE

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Compilation of a 100-year record of landslide locations allows testing of a processbased model for shallow landslide initiation in the City of Seattle, Washington. The model is based on coupling a topographically-driven model for shallow throughflow with the infinite-slope stability model. Three digital elevation models (DEMs) were used to generate predicted patterns of potentially unstable ground: the standard US Geological Survey (USGS) 30 m DEM; a 10 m DEM created from USGS 7.5' topographic contours; and a 1.5 m DEM created from Seattle Engineering Department contours. Model performance varied with DEM grid size, but areas identified as high risk occupy less than 1% of the area of the City. The map of historic landslide locations corresponds well to areas predicted to be at risk for shallow landslide initiation in spite of the extensive hydrologic modifications typical of urban environments and the strong influence of glacial stratigraphy and groundwater flow on landslide processes in Seattle. The unique long-term record of landslide locations indicates that areas predicted to be potentially unstable but that have not yet failed should be interpreted as at risk of failure, as approximately half of the area of potentially unstable ground is associated with known landslides over the period of record. Our analysis indicates that landslide hazards in Seattle are associated with a small but dispersed area of the City that can be objectively identified using simple process models in spite of the hydrologic complexity of the urban environment.

CENOZOIC PALEODEPOSITIONAL SURFACES AND TOPOGRAPHIC INVERSIONS IN HILLY LANDSCAPE OF PARAÍBA DO SUL RIVER MIDDLE VALLEY (SP/RJ), BRAZIL.

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Cenozoic sedimentary deposits have been recognized in the Paraíba do Sul River middle valley (close to São Paulo and Rio de Janeiro border) capping smooth convex hilltops. They were analyzed in detail in hilly compartments bordering the highest relief of the "Serra da Bocaina" and inside the Resende sedimentary Basin, using allo- and morphostratigraphic approaches. The deposits are composed by massive brownish/yellowish clayey sands, deeply weathered, in nonconformity with the crystalline basement or overlying older sedimentary Cenozoic deposits. They were interpreted as a result of sheet wash processes. A minimum Pleistocene age is ensured by the presence of a paleo-horizon A, on their upper part, which is regionally recognized and dated about 10,000 years B.P. Important considerations can be stood out for their interpretation: i) the relationships among geomorphologic settings (different levels of smooth convex hilltops) and the types of soils evolved on them, and ii) their spatial distribution. We propose an origin related to depositional paleosurfaces (pedisements, in the upper levels) or re-featured relict "rampa" complexes (in the lower level). River and gully incisions were responsible for paleosurfaces and "paleorampas" dissection, generating hills in three main topographic levels, resulting on two types of topographic inversions: intra and inter-amphitheater-like headwaters. However, neotectonic controls and/or the presence of local base levels should be considered on the segmentation and/or the simultaneous development of surfaces at different elevations. Similar features and deposits recorded in the reverse slope of "Serra do Mar" suggests a regional meaning of these paleosurfaces.

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GEOLOGIC CONTROL IN THE EVOLUTION OF EROSIVE LINEAR PROCESSES IN THE HERCULÂNDIA AND QUINTANA MUNICIPALITIES- SÃO PAULO - BRAZIL

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The municipalities of Herculândia and Quintana, located in the interfluvium of the Peixe and Aguapeí rivers, west of São Paulo State, present a great gully concentration (erosive linear processes). That feature is due to the occurrence of the lithostratigraphic units belonging to the Bauru Group (especially in the Marília and Adamantina formations), sedimentary sequence essentially sandy with age attributed to the Cretaceous. Several authors discuss the evolution of the erosive processes in the area IPT (1986 and 1995) Oliveira et al (1987), Iwasa et al (1987), Ponçano and Prandini (1987), Queiroz Neto (1988 and 1993) and Pinto (1998).

In the study area it stands out the Plateau of Marília with sharp slopes, interfluvium of the basins. The soils are sandy varying among podzolics and latosols.

The Marília Formation (fine sandstones the medium ones, with cement and carbonate concretions: conglomeratic sandstones and sandstones with carbonate cement), in the study area it is in basal contact, with the Adamantina Formation (fine to very fine sandstones; show locally with carbonate cement and nodule). The transition is made of abrupt change of lithology. The geologic contact among the formations coincides with knickpoint, among the steep slopes, close to the top of the plateau and the hills with convex slopes and low slope angle in the inferior portion. In that knickpoint it can happen the blooming of the freeground water.

That knickpoint can favor the appearance of erosive linear processes. About the Marília Formation (with carbonate cement), gullies appear, that concentrate the overland flow. The flow, of water, when reaching the Adamantina Formation essentially sandy, is associated to the piping, taking to the linear gully appearance.

When the deforestation takes place, in the area of the lithologic contact where are originated the knickpoint, it breaks the morpho-hydro-pedologic balance and transforming that place, where that process occurs in place with high potential hazard to a linear erosion.

BIOGEOMORPHOLOGIC CHARACTERIZATION OF THE RIBERÃO DO CHIQUEIRO BASIN, GOUVEIA, MINAS GERAIS - BRAZIL

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A representative part of the vegetation cover of Gouveia-MG has been deforested over centuries of intensive agricultural activity. The original vegetation was the Cerrado with its variation Cerradão, the Ciliar Forest and the Altitudinal Low Vegetation. The objective of this research is to establish the relation between the physiognomic characteristics of the woody vegetation cover, such as total height, branch height, productivity and structure with the geomorphologic characteristics of the basin. Ten slopes, out of 320, with the occurrence of gullies mapped using aerial-photographs (1:25,000), were selected for sampling on the basis of their occurrence in the basin and of their erosional forms. In each slope, geomorphological sites were identified through the occurrence of break of slope, in the middle of which a soil profile was described and samples collected. The characteristics of the tree strata were also measured using the square method. Through statistic analysis it has been possible to identify high values of the physiognomic characteristics as well as productivity of those trees growing on soils derived from metabasic rocks that occur normally in valleys, amphitheaters and hollows. The minor values correspond to those growing over granite and schist derived soils, occurring preferentially in the upper and middle slopes. Frequency and distribution analysis of the 26 species of trees identified showed that *Eugenia dysenteric* is the most abundant species and the one with the largest distribution. The data obtained corroborated a strong correlation between underlying rock and the geomorphologic dynamics of the slopes, analyzed on the basis of tree vegetation characteristics.

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EMPIRIC-EXPERIMENTAL METHODOLOGY TO DETERMINE FRAGILITY OF HILLSLOPES. A CASE STUDY

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This paper presents a methodology of evaluation of hillslopes fragility focussing the relations between soils properties and hillslopes characteristics. The methodological proposal is based on the use of detailed characteristics of the environment that interfere in the maintenance of the equilibrium of the relief, in natural conditions or in areas where the human intervention has altered the superficial dynamics and had developed processes of destabilization of hillslopes.

The methodological approach uses the correlation among hillslopes units, inclinations and land use, making a map of potential fragility. In other words, soil profiles and collected soil samples. These samples had been analysed in physical characteristics (granulometric sizes, mud content, plastic and liquid limits). Other experiments as cohesion coefficients, had been in field works using Pocket Penetrometer.

As a result of the research cartographic documents had been produced. The Land Use Map had been using aerial photographs and controlled in field works. The Hillslope Inclination Map had been made using topographic maps and degree ruler, and the Geomorphological Map had been using aerial photos, topographic maps and controlled in field works. After maps construction, correlations between spatial information obtained had been made with the information of soil samples and soil experiments, making a new map: The Fragility Map of Hillslopes.

This map has analysed focussing the fragility of hillslopes in function of distinct land uses. The results have demonstrated that it is possible the application of this methodology in humid tropical areas, being indicated for studies of physical territorial planning in detailed scales.

GEOMORPHOLOGICAL ASPECTS OF THE ALCANTILADOS PLATEAU AT THE PREDOMINANCE AREAS OF SILCRETIC ROCKS IN THE DOM AQUINO AND POXORÉO MUNICIPALITIES - MATO GROSSO STATE, BRAZIL

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The Alcantilados Plateau situated in the center-south region of the Mato Grosso State in the interfluvium between São Lourenço and Poxoréu rivers at the Dom Aquino and Poxoréu Municipalities, presented one of the most beautiful landscape sceneries of the state, where the ridge mountains relief presented with planed summit at the board form.

In this compartmentation we can observe the geomorphological process developed itself regionally since the Furnas Formation (Silurian to the Lower Devonian) deposition, until the recent, with the accentuated passages in the Middle to the Upper Devonian (Ponta Grossa Formation), Carboniferous (Aquidauana Formation), Permian (Palermo Formation), Upper Jurassic to the Lower Cretaceous (Botucatu Formation), Middle to the Upper Cretaceous (Bauru Group) and also across of Tertiary in continuance to the Quaternary.

These processes give origin to the abrupt escarped faces and to levels surfaces at the top of the rocks sequence, just as occur in the Parnaíba and Progreso Mountains, which are bordered by echeloned structural crests cut by deep valleys.

The leading factor is referred to the top portions with the presence of hard crusts and siliceous pavement of flagstones locally, constituted by the silcretic rocks in association with fibrous silica compounds, carbonated rocks with traces of manganese and iron, referred the Cachoeira do Bom Jardim and Cambambe Formations depositions, to form a part of the Bauru Group.

Some studies which are being developed with relation to siliceous migration since the top until the base of predominance of rocks sequence regionally and which constitute the Alcantilados Plateau conduct us to idealized new concept, about the formation of these silcretic crust, and its resistance to the erosive processes, common in other areas of the plateau.

PALAEOGEOMORPHOLOGICAL INVESTIGATIONS OF DEPRESSED TERRITORIES (ON THE PATTERN OF KUR DEPRESSION)

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Kur depression covering a considerable part of the territory of Azerbaijan is a standard for study of buried palaeorelief of depressed territories. The huge thickness (about 15 km) of sediments here buried in themselves many atored heterogeneous and heterochronous palaeorelief. In order to reestablish it there are great numbers of data of different kinds of wells and geophysical materials allowing to use successfully the methods of analysis of facies and thickness of lower pliocenepleistocene sediments (prepliocene revelations are isolated) for reestablishing the buried relief in given interval. There is no need to speak about the obviousness of the method actualism. The logical construction in the work of reestablishment of palaeorelief is simply necessary, without them it is impossible to use any methods. The palaeomorphological investigations related to Kur depression allowing to reestablish enough in detail the pliocenepleistocene relief of basins have been carried out by us. These investigations at the same time bear an applied significance, as the entrails of this basin are rich with the fields of oil, gas, underground fresh waters, building materials, etc.

The quintessence of these investigations is the maps of Kur depression compiled by us where it is shown the genetic types of relief both in land and in the bottom of sea, separate forms of relief, lithology of rocks, age, boundaries of sea basins and others. Compiled stage by stage, they illustrate the origin and development of separate morphostructures, beginning of appearance and development of mudvolcanism, rupturing tectonics, etc.

These maps have also a great applied significance. So, for example, the areas and forms of relief (bed and delta of rivers, alluvial cone, bars, spits, etc.) given there are perspective for searching there the oil, gas, underground fresh waters, building materials, etc.

REGIONAL CHARACTERISTICS AND CONTROLS OF DEBRIS FLOWS IN SOUTHWESTERN BRITISH COLUMBIA

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The humid, forested mountain landscape of southwestern British Columbia can be characterised as a debris flow dominated landscape; yet it was not until 1972 that attention was first drawn to the importance of debris flow in this region. The reasons for debris flow dominance over other slope and channel processes include the continuing response of the land to Cordilleran ice retreat, through over-steepened slopes and enhanced sediment supply, the dense rainforest vegetation and the increasing population and land use pressures to which the mountains are subjected.

We can recognise five broad categories of regional controlling variables, namely geologic, morphometric, hydrologic, sediment recharge and anthropogenic factors as follows:

Geologic: Debris flows generated from Quaternary volcanic complexes differ from those in coarse textured plutonic rocks;

Morphometric: Basins from 1-5 km² in area and with channels 25-300 m in slope appear to be most active;

Hydrologic: Runoff intensities associated with orographically enhanced frontal disturbances, rapid snowmelt, release from lake storage and log jam bursts are triggering mechanisms.

Sediment Recharge: Basins can be characterised as either weathering- or transport-limited, and factors that are influential in this context are the availability of unconsolidated sediment and the role of organic debris and

Anthropogenic: Widespread urbanisation, intensive recreational use of the mountains and indiscriminate logging have increased debris flow incidence locally and regionally.

Development of terrain and slope stability mapping and new provincial guidelines for forest practice have been the main assessment and mitigation devices implemented.

QUANTIFYING THE INFLUENCE OF THE RELIEF ON THE AMAZONIAN LANDSCAPE DYNAMICS

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The study of landscape dynamics in Amazonia requires a good understanding of the processes that rule land-use conversion, agricultural land abandon and forest recovering. To achieve such goal, one needs to develop new methods to map as well as to analyze spatial patterns resulting from changes induced by these processes. These methods will in turn enable the formulation of reliable models to operate at regional scale.

On these basis, this work aims at the development of methodology to obtain spatial transition models using mainly remotely sensed data and topographic maps. This study was done using an area located in the northern part of the state of Mato Grosso (Brazil), that stands as a typical Amazonian Frontier Colonization region. Map algebra was applied in order to generate the selected variables needed for the change analysis, e.g. slope, altitude, vegetation, soils, urban attraction, road buffers and distance to selected landscape elements. This process was done within a Geographical Information system (GIS) environment combined with multivariate statistical techniques. It could be shown that the maps resulting from the *logistic regression* gave a good indication of the areas most favorable for each type of transition, consequently they could be interpreted as maps of the spatial transition probabilities.

In addition to the quantified effects of the above variables, the relief, represented by the slope and altitude variables, showed a negative influence on the selection of sites to be deforested, and a positive effect on the abandon and regeneration processes that take place in the cultivated and pasture fields. Besides these results, the methodology developed represents an important step towards the discretization of landscape dynamic simulation models into sub-areas.

QUATERNARY EROSION RATE ESTIMATES FOR ANCIENT AUSTRALIAN CRATONIC SURFACES

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The cratonic surfaces of Australia represent one of the most stable landscapes on Earth. Features formed close to the land surface in early- and mid-Tertiary times, such as deepweathering profiles, silcrete and palaeochannel fills, are widely preserved indicating extremely low average erosion rates. We are investigating whether Quaternary erosion rates on these surfaces are compatible with their long-term preservation, or have increased to levels above the long-term average. The latter scenario, which might reflect Quaternary climate changes, has been invoked to explain preservation of ancient Australian landscape features. To address this question, we are combining ⁴⁰Ar/³⁹Ar dating of supergene Mn oxides and sulfates, to determine sub-surface weathering ages, with cosmogenic isotope studies, to measure erosion rates of the overlying duricrust surfaces over the past few million years.

Initial results covering three morphological and climatic provinces in the Mt Isa region of northern Australia show a roughly inverse correlation between erosion rates and weathering ages. The highest erosion rates, of 2-4 m/Ma, occur in the area of highest present-day rainfall, where deep-weathering ages are 3-6 Ma. Landscape surfaces in the more arid regions of the study area give much older weathering ages (up to 50 Ma) and lower erosion rates, on the order of 1 m/Ma or less. Thus far, the comparison between short-term erosion rates and long-term preservation of weathering profiles does not call for significant increases in Quaternary erosion. A more extensive data set will be presented at the meeting.

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NEW STRATEGIES FOR UNDERSTANDING LANDSCAPE EVOLUTION

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Studies of long-term landscape development have traditionally relied to a significant extent on the interpretation of morphological features, such as erosion surfaces and river long profiles, and their correlation with deposits of known or inferred age. The success of this approach has been limited by the paucity of datable deposits due to the preponderance of net erosion in most landscapes. Thermochronology and cosmogenic isotope analysis, however, are two sets of techniques capable of providing valuable estimates of long-term denudation rates in eroding landscapes by quantifying the time elapsed as a rock sample moves from a known depth to the surface. For the majority of geomorphological applications the most useful thermochronometer is apatite fission-track analysis. This can yield cooling histories across a temperature window from ~125 to 60°C which can be used to infer denudational histories for crustal depths of up to ~4 km for common geothermal gradients. Recently, partial retention of He between ~75 and ~40°C has been demonstrated in the U-Th/He system and this could potentially be used to estimate denudation at shallower depths of ~2 km.

The regional-scale variations in long-term (10^6 - 10^8 a) denudation rates inferred from these thermochronological techniques can be combined with more site-specific data from cosmogenic isotope analysis which yield estimates of denudation rates over shorter timescales of 10^3 - 10^6 a. The integration of these complementary techniques, and their role in constraining landscape evolution models, is illustrated with reference to the development of the landscape of southern African using data from ^{10}Be , ^{26}Al and ^{36}Cl cosmogenic isotope analysis and apatite fission-track analysis.

PERSPECTIVES ON TROPICAL GEOMORPHOLOGY

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Geomorphology in the tropics faces a number of contradictions. Most water-based processes proceed more rapidly in the humid tropics (and sub-tropics), including rock decay, mass movement, sometimes sediment transport. Yet, while mainstream geomorphology has pursued event-based studies of surface processes, geomorphology in the tropics is accused of emphasising models of long-term landform development within 'cratonic regimes'. Calls are made to abandon such traditional concepts and to embrace process studies of more direct relevance to sustainable development. But one key to understanding many economic and environmental issues (mineral resources, basement aquifers, slope failures, soil erosion), is the chemical decay of rocks and the transfer of weathering products as colluvium. The role of this regolith cover is neglected in many texts, and the development of geomorphological theory is constrained by this neglect, through attempts to limit the relevance of weathering to tropical cratons or temperate palaeoplains.

Weathering rates in the humid tropics allow the formation of deep saprolites within Quaternary time and demonstrate the importance of weathering in Neogene terrain, while the antiquity of many weathered mantles has also been demonstrated. A fresh perspective on the role of weathering as a landforming process is required; one which focuses weathering in all environments (climatic, tectonic, lithologic). This can be linked to studies of episodic erosion on timescales from those of the cratonic regime, through the Quaternary climate oscillations, to the impact of individual events. The viability of geomorphology as an earth science depends on its wider relevance and the quality of its explanations. Studies from the tropics can offer many insights of importance to higher latitude research as well as vice versa, and new work on 'regolith studies' should offer one such example.

$^{40}\text{Ar}/^{39}\text{Ar}$ WEATHERING AGES FROM ANCIENT AUSTRALIAN CRATONIC SURFACES

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Stable cratonic regions of Australia are often characterized by stepped landscapes, where relatively flat land surfaces occur at distinct elevations. The relative topographic position of these surfaces, the depth and complexity of their soils and weathering profiles, and their stratigraphic relationships have been used to correlate these land surfaces on a regional, cratonic, and even worldwide scale. $^{40}\text{Ar}/^{39}\text{Ar}$ dating of minerals precipitated in weathering profiles provides a quantitative means of testing such postulated correlations.

$^{40}\text{Ar}/^{39}\text{Ar}$ dating of more than 500 samples of supergene Mn-oxides (cryptomelane and hollandite) and sulfates (alunite and jarosite) from 13 distinct weathering profiles hosted by surfaces at different elevations in the Mount Isa Region, Australia, indicates that the regional scale correlation between these surfaces is possible. Weathering ages vary according to elevation. The higher elevation weathering profiles (400-500 m) yield the greatest ages (65-70 Ma). Weathering profiles hosted by intermediate elevation surfaces (280-320 m) yield relatively younger results (12-25 Ma), while weathering profiles hosted by the lowest elevation surfaces (160-200 m) yield the lowest weathering ages (0.7-6 Ma). Long-term erosion rates obtained from the differences in elevations and weathering ages between the surfaces range from 2-4 m.Ma⁻¹.

Erosion rates for the dated Mt. Isa weathering profiles, obtained from cosmogenic isotope (¹⁰Be, ²⁶Al, and ³⁶Cl) abundances, indicate that the lowest elevation surfaces (youngest weathering ages) correspond to the highest erosion rates (2-4 m.Ma⁻¹). The higher elevation surfaces, hosting the oldest weathering profiles, yield the lowest erosion rates (ca 1 m.Ma⁻¹). The variation of erosion rates with landscape position accounts for the preservation of older weathering profiles at higher elevations. The variation in erosion rates also suggest that landscape evolution in the areas studied occurs primarily by scarp-retreat and not by a Davisian-style surface ablation. The results also indicate that long-term erosion rates for the Cenozoic, obtained from weathering geochronology, do not differ significantly from Quaternary rates obtained through cosmogenic isotope measurements.

COMPARISON BETWEEN DIFFERENT PROCEDURES TO OBTAIN CONTRIBUTION AREA MAPS: APPLICATION TO LANDSLIDE HAZARD MODELS

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Landslides are common processes in Rio de Janeiro, mainly during heavy summer rainfalls. These natural phenomena normally occur due to a complex combination of natural and human-induced factors. It is evident that the topographic hollows are characterized by landslides hazards because these areas are frequently saturated by water and filled up by colluvial soils. A physically-based model for the topographic control on shallow landsliding, combining a hydrological model and a slope stability model, has been applied to predict landslide hazard areas in an experimental basin. The hydrological model is based on soil properties and on morphological attributes, mainly contribution area and slope. Contribution area maps represent important tools to define, from a DEM, the location of hollows in the field, helping in the prediction of saturated zones, inundation areas, drainage networks and landslides. In this work we calculate, from a 2 meters grid DEM, the contribution area maps of a 2 Km² basin using two different procedures. In the first, we developed an algorithm and used it in an inexpensive set of hardware and software, under a PC platform. In the second one, we used a robust software under a workstation environment. These procedures were applied to a basin in which many shallow landslides were triggered after intense rainfall in February 1996. The two procedures have presented different results. For example, only the second procedure was able to predict the location of hollows in the field, with good accuracy, the values of each pixel contribution area. Besides, this procedure was able to extract the drainage network, with high resolution, from a DEM. The results suggest that the second procedure may improve the performance of landslide hazard models.

RELATIVE INFLUENCE OF CONTROLLING FACTORS ON SHALLOW LANDSLIDES TRIGGERED IN THE PAPAGAIO BASIN, RIO DE JANEIRO

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Many factors control the generation of shallow landslides in the tropical steep slopes of Rio de Janeiro (e.g., soil properties, inherited rock features, vegetation cover, hillslope morphology and subsurface hydrological conditions). During the last few decades, these relationships became even more complex due to the spreading of human occupation towards the hills. In order to characterize the role played by each one of these factors, it has become relevant to combine field monitoring and mapping with mathematical models based on physical laws.

This study aims to evaluate the relative influence of some controlling factors on the extensive shallow landsliding that took place in February 1996 along the Papagaio basin (RJ), combining field mapping with simulations using the SHALSTAB model, developed by Dietrich and Montgomery (1998). To carry out this investigation a small sub-basin was selected, where landslides took place on only one side of the valley. Landslide scars and vegetation cover were mapped from aerial photographs and field work while contribution area and slope maps were obtained from a high resolution DEM.

The results showed a good agreement between the predicted unstable areas and the location of landslide scars from 1996. The differences observed on the distribution of vegetation cover alone, degraded forest in the hillslope dipping south and grass in the one dipping north, do not justify the instability predicted by the model for this last one, because the simulations neglected cohesion, hence the direct effect of vegetation. The results attest the major role played by hillslope morphology, specially slope and contribution area of each cell in the basin. In order to accomplish a better understanding of these complex relationships, future research should include detailed field mapping of soil and rock properties together with new simulations for other possible scenarios.

PLANATION SURFACES WEATHERING PROFILES AND AGE OF THE TANDILIA RANGE, BUENOS AIRES, ARGENTINA

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The Sierras de Tandil is NW-SE trending mountain system, 300 km long with altitudes between 50 and 250 mts above the surrounding pampean plain of Buenos Aires province. The range is composed of Proterozoic crystalline basement which belongs to the Brazilian craton, unconformably overlain by Precambrian and lower Paleozoic sedimentary rocks. The purpose of this contribution is to analyse the geomorphological evolution of the range within the frame of the tectonic history of the South Atlantic Ocean and the sedimentary filling of neighboring basins.

Three planation surfaces are recognized along the mountain range and interpreted as long-term geomorphic features. The oldest planation surface (pre-Cretaceous or prerift surface) is represented by the levelled summits of the highest ranges near Tandil (altitudes above 450-500 asl). No weathering profiles are associated with this surface.

The intermediate planation surface (late Jurassic-early Cretaceous to mid-late Tertiary or postrift surface) is the most extensive with altitudes increasing from SE to NW (200 mts to 350 mts) and dipping slightly towards the SW. Corestones, concentric weathering rinds, granitic gneiss and kaolinized crystalline rock profiles are associated with this surface. In some areas, present soils are partly developed on weathered granitoid rocks. The characteristics and distribution of the weathering features suggests they correspond to the root of a weathering mantle which was probably stripped away in the early to mid Cenozoic. The youngest planation surface (initiated during the Oligocene?-early Miocene?), displays some moderate weathering and is covered by a late Cenozoic apron (Pliocene-Pleistocene and Holocene) of eolian deposits (mostly loess and loess-like deposits) over which present soils are mostly developed.

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DISTRIBUTED MODELLING OF THE WATER EROSION PROCESSES AT THE EVENT SCALE AND CUMULATIVE RASTER ESTIMATES OF ITS

LONG TERM APPLICATION IN EXPERIMENTAL BASINS

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The water erosion modelling in small catchments is developed on the distributed runoff model, by their coupling at the raster scale and 10 min time intervals.

In distributed runoff modelling, the output hydrograph is estimated by integrating space and time variables of the water balance components over the catchment area. The basic idea is that only taking into account in the computing process of a larger number of variability factors, the estimation accuracy may be increased, due to the use of more proper averaging scales of the involved variables. The basin digital terrain model stands for the numerical integration domain of water depth values, whereas physically-based models of the water balance components may be easily tailored to the local terrestrial peculiarities by means of a constant parameter set has been verified on several events. The time dependence is given by two infiltration parameters characterising the soil moisture dynamics as short and long term behaviours, being estimated in terms of the previous rainfalls' occurrence.

The rain erosivity at the impact with the land surface is estimated by means of a linear function of 10 min rainfall intensities, where the scale parameter has a time evolution exponential law due to a soil moisture effect. The sediment source is a distributed variable according to the area variability of rainfall input and interception losses, and a potential amount for the sediment transport.

The sediment transport rate is a two-parameter parabolic function in terms of local water discharges. Under the circumstances, the usual high non-linearity of the process at the catchment scale is reduced at similar shapes like the runoff one, being dependent on a combined scale parameter of the above processes, to be updated at the analysed event by means of a time constant in the exponential function and the initial state according to the soil short term behaviour. The fixed parameters may be easily estimated from simulated successive events.

In framework of the local sediment balance, the process non-linearity may lead to bed erosion in case of a higher output than input, and, otherwise to sediment deposition. The sediment dynamics is also available in framework of area estimates all over the computing period at each 10 min time step either in case of washed materials from the potential amount, or as cumulative values in the transport process.

Being highly connected to the catchment land cover and topography, reasonable predictions may be performed at the event scale for hydrologic effects being generated by different land cover changes, as well as long term estimates due to an acceptable accuracy the time evolution of the soil system may be described.

The numerical examples in the paper refer to simulations of successive events, predicted effects on runoff and suspended load hydrographs at scenarios for watershed afforestation and cumulative effects on a long period to be compared with two topographic maps at a 25 years' interval.

THE RELATIONSHIP BETWEEN GULLY EROSION AND LAND USE IN GOUVEIA, MINAS GERAIS, BRAZIL

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In Gouveia, MG, gullies are one of the most striking features of the landscape. Their occurrence is restricted to the areas whose geological substratum is formed of granit-gnaisses from crystalline basement and by schist, basic and metabasic rocks. These are also the only areas with the presence of soils to support agricultural activities. Where quartzite from Espinhaço Supergroup predominates, only arenosols or very sandy lithosols occur. Mapping of gully spatial distribution shows a close relationship with the pattern of some type of land use and management. From the 66 mapped gullies occurring in Tombador, Padre and Tamanduá basin, 73% are localised in hollows and amphitheatres in association with the presence of different types of fences; 18% are present in mining areas and 9% are close to roads or paths. There are three most frequent types of fences in Gouveia. There is an old wall constructed with stones, remainders of slave times, with no presence of gullies associated. A second type is the common wire and wood fence used until today. In order to minimise the costs the farmers use only two or three lines of wire constructing at the fence side a small levee-like structure. Beside it a long depression is opened to protect the levee against runoff. It concentrates the running water inducing gully processes to take place. A third type, also not very much used today, is a long trench opened to divide properties and, in some cases, to protect small agricultural areas from the invasion of cattle. Most of them were transformed into gullies through the action of surficial water concentration. The most effective mechanism of vertical incision is the direct effect of the concentrated runoff along the valley bed while lateral expansion occurs mainly through mass movements. Structural characteristics of the underlying rocks play an important role in defining lines of preferential lateral retreat. Preliminary results of geochemical analysis of the soils pointed out the influence of iron content in the occurrence of piping associated to the gully processes. Although the study confirms a close relationship between the occurrence of gullies and the type of land use, correlative deposits of a similar type of process dated with C^{14} (δ^{13}), corresponding to the Laschamps subchron has been found in the area.

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GULLIES AS BIODIVERSITY CORRIDORS: A CASE STUDY IN GOUVEIA, MINAS GERAIS, BRAZIL

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Gully systems are part of the agricultural landscape of Gouveia-MG, southeast Brazil. They occur especially in agricultural soils formed by granit-gnaiss of the crystalline embasement and from schist of the supergroup Rio Paraíba. Gullies are responsible for significant losses of agricultural lands. They occur at different stages of evolution in the Chiqueiro basin where, however, approximately 60% of the 320 identified and mapped gullies are already stabilised. This stabilisation has created conditions for a more developed and diversified vegetation to grow as well as for more animal species to establish in the interior of these erosional forms. Today they play an important role as biodiversity corridors especially considering that Gouveia has a very degraded environment. As a result of intensive land use and weathering processes, the soils of the area are very poor in macro and micronutrients, thus being unable to ensure a denser and higher natural vegetation cover on the slopes. Inside the gully, younger soils, even if only lithosoils, provide greater concentrations of those nutrients, presence of water or more humid conditions almost all over the year, besides protection against the effects of seasonal burning. These seem to be the most important factors responsible for the existence of the corridors. Inside the gullies it was observed the occurrence of the same vegetation species as that occurring on the slopes, although three times denser and higher. There were also detected species from the fauna, which are not present on the slopes, suggesting that this boundary makes the gully-systems even more important for the preservation of fauna. The connection between gullies and the water streams of the area assures the flow transfer of this biodiversity through the entire system.

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THE EVOLUTION OF GULLY PROCESSES IN THE TRIANGULO MINEIRO, MINAS GERAIS - BRAZIL

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The study area is located in the domain of the savannas, plateaus and residual relief sustained by rocks of the Bacia Sedimentar do Paraná.

Research started 10 years ago and from geomorphological mappings, classification and zoning of the gullies, sample hidrographical basins were established: The Boa Vista Brook basin, in the municipal district of Prata, and the basin of the Douradinho brook, in the municipal district of Uberlandia.

Studies in the Douradinho Brook showed receding of the banks of the gully of up to 3.00m, between 1997 and 1998. The erosion incursions occur of walls due to a line of pipe flows. Underground caves develop originating from the dynamics of the ground water causing seepage erosion. Such processes are promoting interfluvial dismantling because of receding headwaters as well drainage caption. The Boa Vista Brook presents, in the segments of the coluvial ramps and at the base of cliffs, gullies with a depth between of 10 to 20m dating back from 20 to 50 years with a receding headwaters of up to 4.70 m, between 1996 and 1998. In the monitoring of the gullies, an expressive dynamic was noted in some digits conditioned by the superficial runoff and pipe flows.

An intensification of the erosive fronts by gully in the savanna shows a direct correlation to receding drainage headwaters at several dissection levels indicating an erosive retake set off through natural processes and accelerated in the last 100 years by the use and inadequate occupation of the soil.

MEASURING SOIL LOSS AND EXPERIMENTAL STUDIES IN IRAI DE MINAS, MINAS GERAIS - BRAZIL

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Studies are being pursued in Irai de Minas by monitoring of the sheet runoff and measuring soil loss in plots in two differentiated microbasins from the morphological and landuse points of view.

The Pantaninho brook is located at the top of the plateau in smooth relief with declivity, 3 to 8% and an altitude of between 1000 and 1065 m. The clay-silt-sandy soils are covered by the cultivation of soy and corn by conventional or direct planting. The results presented in the plots of 1 x 10 m in the year of 1998 were: precipitation (P) 1810 mm; runoff in the portion of exposed soil was (R) of 633.7 L and soil loss (SL) of 136.86 Kg; in the portion with soy, R = 220 L and SL = 47.13 Kg.

The Divisa brook is located on the boundary of the plateau, in with strong structural ruptures, declivity of between 5 and 27%, embedded valleys, convex and rectilinear slopes between 850 and 1000 m high. The clay-silt-sandy soils are covered by the pasture. Precipitation in 1998 was: (P) 1019.67 mm. Results in the plots were: the part with exposed soil presented: (R) 319.3 L and, (SL) 68.91 Kg; in the grassy part the (R) was 103.95 L and (SL) 8.43 Kg.

The granularmetrical analyses of the loaded material carried away indicated a greater removal of silt particles, and a smaller loss of clay and sand. There was evidence of significant crusting of the soil as well as vident action by rains causing splash erosion with detachment up to 35 cm or above.

RECURRENT GULLYING IN A SMALL DRAINAGE BASIN, OURO PRETO (MINAS GERAIS), BRAZIL

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The gullies ("voçorocas") are concentrated on area of arquean basement rocks (gneisses, migmatites and granites), which are covered by tens of meters (up to 50 m) of saprolite and by some meters (up to 6 m) of elluvium (residual soil) or colluvium.

Two main phases of gullying were identified: the first is characterized by reshaped gullies (amphitheater-like hollows), with smoothed scarps, partially filled with alluvial-colluvial sediments (ramps) of upper quaternary age. These sediments are connected to deposits of fluvial terrace (T1, about 6 meters above the current floodplain). The second erosion phase is connected to the current drainage system and is characterized by gullies with well-marked scarps, hummocky bottoms, which developed as a consequence of deleterious land practices in the last 300 years. The gullies of the second phase frequently follow the hollows of the first one (eroding their sedimentary filling) and widen to huge digitated forms when they reach the rock saprolites. Coalescent gullies due to the interfluvial erosion are common features.

A geomorphological and a detailed stratigraphic analysis have been conducted as well as a structural analysis in order to explain these types of gullying and to understand how erosion begins, succeeds and stops. Preliminary data show that the gullies are structurally controlled.

The residual soil/colluvium are more resistant to erosion than the saprolite, thus the erosion only grows when the subsurface mechanisms are activated. Superficial washing over scarp (plunge-pool) or collapsed materials and retreat of scarps by collapsing or slumps are other mechanisms. The choice among different erosion management options should be based on these data.

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GULLY EROSION AND TUNNELING EROSION ON THE SOUTHERN "SECOND PARANÁ PLATEAU" (BRAZIL)

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The Southern 2nd Paraná Plateau presents great variety of erosive processes. Two of them are expressive at a regional scale: gully erosion and tunneling erosion. At a regional scale, previous studies point to a weak correlation between the morphometry of hillslopes and the gully dimensions (r coefficient ranging from 0,04 to 0,40). Otherwise, the relationship between gullies orientation and regional joint patterns seems to be outstanding, mainly at N10-30E and N50-70E. Gully evolution during the last 15 years, by the use of aerial photographs, suggest that different lithologies of the Itararé sub-group should be important to gully erosion rates. Field attempts to estimate erosion rates between 1995 and 1997, by the use of plani-altimetric polygons, suggest that the most important erosion rates (38.19 and 177m³ per year) occur on gullies connected to main drainage system, that is, which evolution depends on the rates of subsurface water flow. Hydromorphic soils are very common in this area; they develop under the influence of either impermeable soil horizons, or shallow fresh bedrock, creating lateral subsurface flow and seepage zones on the gully walls. Tunneling erosion develops further and may create broader erosive features, under the influence of concentrated water flow into the tunneling network. At a regional scale, tunneling erosion define the main drainage axis on hillslopes. These axis often presents topographic subsidence and develop a pseudo-karstic topography, with tunnels and wells. Evidences suggest that those erosive processes are natural processes which had been acting in the region during the last 40,000 years.

EROSION PROCESSES ON THE STREAMHEAD OF ARAGUAIA RIVER BASIN (MATO GROSSO AND GOIAS STATE, BRAZIL)

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Gully erosion is one of the major problem of soil degradation on the streamhead of Araguaia river basin, which is about 76,000 km².

The gullies in the Araguaia region have been developing for almost 20 years ago. They are the result of land use actions (part of the savannah - cerrado - was replaced by grass and soya bean culture), which cause the complete alteration of the ecosystem.

The mapping around all the drainage basin area has shown that evolution process of that gullies is dynamic, intense and continuous. Some of them are 30-40 meters deep, and sometimes reach 1.5 kilometers length. Sediments yielded by gullies are delivered to the stream courses causing the silting up of the Araguaia river.

Regarding this situation, it has been developed the project "Recovery of the Araguaia river streamhead Programme", undertaken by Mato Grosso and Goiás State Governments. Based on the methodological approaches and experiences of IPT (Institute for Technological Research) and DAEE (Water and Energy Department), it was developed a gully erosion emergency control plan for the biggest and worse gullies in the basin.

Each one of the gullies were recognized and it was prepared a report related to the characteristics of the gully, the direct influences in the area and summarized all drainages which contribute into the gully. The work was based on investigation of the characteristics of dynamic processes, analysis and evaluations of the gullies and their main damages. It was collected some samples for soil analysis. It was also prepared sketches of the gullies and the drainage basin which have been used to make the control projects. In these sketches it was pointed out all the measures of the gully (dimension, extension, etc.). The stream flow in several points along the gully was measured as well.

Finally, all information were used in order to indicate the methods be applied for the control of each one of the gullies.

HYDRO-BIOPHYSICAL INDICATORS OF EROSION IN THE WATERSHED OF PEREQUÊ RIVER, "SERRA DO CUBATÃO", "SERRA DO MAR" STATE PARK - SÃO PAULO STATE

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The Pereque watershed is localized between 24° 10' e 24° 30' South Lat., e 46° 18' e 42° 30' West Long., with 2,300 ha and altitude between 16 and 859m in the steep relief. The study aims to establish relations among the morphodynamic and geomorphology, geology, pedology, vegetation cover and slope using photointerpretation, field works and information crossing. Two hydro-biophysical macro sectors were obtained. One consists of the upland border and the steep relief where it has predominance of pinnacle tops with declivity above 25°, pronounced declivity rupture, abrupt changes of convex-rectilinear slope to rectilinear slope what shows important lithological and structural influence in the forms of relief compartment and erosion process distribution. There is strong degradation of the natural vegetation on the migmatitic rocks, not much resistant to the erosion process, that associated with the few deep soils (Insepsol, Lithic entisol and rock) presents several types of forms with much concentration of landslides. The other macro sector consists of the convex tops with less density of landslides, declivity below 25°, degraded secondary vegetation and little degraded vegetation over soils more deep (oxisol). In the low and medium slopes with declivity less than 15°, sediment and debris accumulation occur what characterize changes of abrupt rectilinear slope to concave slope. Therefore, the "Serra do Cubatão" steep relief presents high erosion susceptibility, indicated by the hydro-biophysical components; the continuous degradation of the vegetation in the area causes apprehension due to the probable speedy reactivation of the landslides.

VALIDATION OF THE WEPP WATERSHED MODEL FOR A SEVERE EROSION EVENT ON THE BREAKY BOTTOM CATCHMENT, SOUTH DOWNS, UK

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When the predictions of physically-based soil erosion models are validated against measured data, a recurring theme is 'the right answer for the wrong reason'. Such spurious precision can occur in both temporal and spatial senses. For example, an acceptable estimate of long-term average erosion rate may mask unrealistic underlying distributions of annual, monthly or event values (Favis-Mortlock, 1994).

Similarly, a reasonable estimate of sediment yield at a catchment outlet may result from a simulated field-by-field pattern of erosion which is simply wrong (Jetten et al., 1999 in press). It would clearly be unwise to put much faith in other predictions by models which show this kind of behaviour.

The way to guard against such problems is to validate more than one model output against measured data. The relative abundance of time series of measured data for plot- and field-sized areas means that unrealistic temporal distributions of modelled erosion rates are not difficult to identify. It is less easy, however, to validate the spatial patterns of erosion which are estimated by current models, since suitable field measurements are rarer. But we must undertake such validations at a catchment scale, if we are to improve the ability of current models to estimate the soil loss which results from the development and growth of ephemeral gullies (Poesen et al., 1998).

This paper examines the ability of the watershed version of the WEPP model (Flanagan and Nearing, 1995) to estimate the spatial pattern of erosion on a 189 ha agricultural catchment at Breaky Bottom, in the UK South Downs. Fields on this catchment eroded severely in October 1987 during the most serious erosion event to have been recorded in Britain (Boardman, 1988).

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ENVIRONMENTAL IMPACTS DUE TO GULLY EROSION IN CÁCERES MATO GROSSO

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The study area is located 12 kilometres from Cáceres, at a place called Gleba Facão. Rill and gully erosion are spread in this area, due to land use mismanagement. To carry out this investigation, several field works were made, in order to monitor the gully evolution, using stakes to measure the gully growth, as well as several soil samples were collected in order to be analysed in the laboratory, so that soil properties could be determined.

The slope where the gullies were monitored showed a very high sand content, usually ranging between 50 and 78%, and silt content usually between 10 and 30%, while the clay content is usually below 15%. Also most slopes where the gullies retreated more rapidly showed a low organic matter content, ranging between 1% and 3%. Another parameter which has been determined is the water stable aggregates, which showed very low results for the eroded area.

As a consequence of the spreading soil erosion at Gleba Facão, there has been silting of the rivers, rills and gullies are spreading in the area, as well as agriculture is suffering the effects of erosion, because the soil is losing organic matter content, as well as decreasing its nutrients. The investigation, therefore, shows how the gullies are growing in the study area, together with the slope characteristics and how soil properties and land use affect the whole erosion process.

APPLICATION OF REMOTE SENSING FOR GULLY EROSION: A CASE STUDY

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Over exploitation of available natural resources for meeting the increasing demand of ever growing population for food, fuel and fibre has led to serious environmental degradation. Globally, an estimated 1,965 million hectare of land are subject to some kind of degradation. Of this, 1,094 million ha land are subject to soil erosion by water and 549 million hectares of land to soil erosion by wind. In India alone, out of 329 million hectares geographical area, an estimated 150 million hectares of land are subject to soil erosion by water and wind erosion. Furthermore, an estimated 3,975 million hectares of land are highly dissected and have an intricate network of gullies.

In a broad geologic sense, erosion means wearing away of the earth's surface by the forces of water and wind. Soil erosion could be either natural or accelerated. Natural erosion in the natural landscape may be either a gradual process, with a soil cover on the land continuously or a catastrophic one. Natural erosion is important in soil development. Accelerated soil erosion truncates the soil profiles formed in the natural landscape. In applied soil science and agriculture, erosion is used in a restricted sense. The terms "erosion" and "soil erosion" are often used for accelerated soil erosion, or that erosion of soil resulting from disturbances of the natural landscape, usually by man in contrast to the natural or normal erosion that takes place in the disturbed landscape.

In the present paper efforts have been made to identify the gully erosion areas along the Chambal River using Remote Sensing Techniques. The study also shows the extend, pattern, status of gully erosion, and their depth where reclamation measures can be taken to arrest the soil erosion.

HILLSLOPE EROSION - STRATEGIES OF DEFENCE

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In the region of the left side of the Lower-Rhine in North Rhine-Westphalia there is a push moraine. The hillside facing the former moraine is more steeply formed while the terrain on the other side shows a flat westward hillside. The fertile soils are agriculturally used. After heavy rain falls run-off causes large losses of soil on the east slope side. In the autumn of 1998 ditches and also gullies (up to 1.8 m depth, 1.5 m with and several 10th of metres long) occurred. The eroded soil material is deposited in the fields on the bottom of the ridge, on residential areas which border the ridge and cause a lot of damages on the traffic network, the sewage and on buildings. Field and laboratory investigations showed that these intolerable soil erosions are caused by long stretched hillslopes (up to 600 m) without dividing transverse structures, from puddled soil surfaces and from the intensive growing of crops which cover the soil late in the vegetation period. In order to protect the fields and the residential areas permanently from the impacts of the soil erosion a work group is active to devise a basic plan. The intention is to introduce plant production measures against erosion, as well as a decreasing and preventing tillage by changing the crop production. These measures can be combined with hillslope division elements. A further important constituent of this concept is to develop a method how to deal with major soil erosions. This method, will be published in a manual, guiding people concerned with similar soil erosion problems on other places in Germany.

WATER EROSION ASSESSMENT BY GEOPROCESSING THE UNIVERSAL SOIL LOSS EQUATION (USLE) IN THE HYDROGRAPHIC BASIN OF JURUMIRIM RIVER - ANGRA DOS REIS, RIO DE JANEIRO, BRAZIL

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The objective was to make a water erosion vulnerability map to the scale 1:25,000, by geoprocessing USLE, in order to identify erosion threatened areas and help the future planning of land use and environmental management of the drainage basin. The watershed is located on the rural zone of Angra dos Reis, RJ (22°50'19"/22°55'52" S and 44°13'53"/44°19'41" W). It's in the domain of Serra do Mar, presenting rough topography, with gradients ranging from sea level to 1246m, in an area of 68km². The lithology is constituted of Precambrian granites and gneiss and Quaternary fluviomarine deposits. Cambisols (17% of the area) occupy the greatest altitudes and slopes, Acrisols (31%) are in the base hillslopes and in basal hills and the fluvisols (16%) occupy the plain. The mean annual rainfall is 2,100mm, with more than 200mm monthly values. The drainage length totalizes 139km. The Tropical Rain Forest covers 61% of the area, mainly in the highest and steepest hills. Other land cover and economic activities are banana plantations, cattle ranches, sand and stone quarries. When applying USLE in a GIS, the product of soil erodibility and topography maps with the rainfall erosivity factor, allowed assess the Natural Erosion Potential, which can be very high in 22% of the basin. The most threatened sites are the ones that have lithologic soils, mountainous relief, slope length above 100m, slope steepness greater than 50%, and altitudes greater than 400m. After introducing the land use/land cover map, 51% of the area yields less than 1 t.ha⁻¹.yr⁻¹. Comparing the Actual Erosion map and Tolerable Losses allowed identification of critical sites where the actual erosion is larger than the tolerable limit (36% of the area). With the help of ancillary data available from the local authorities it was possible to recommend a more sustainable management plan for the watershed.

JOINT-CONTROLLED GULLYING IN THE PIRACEMA-BANANAL BASIN (SÃO PAULO-RIO DE JANEIRO): THE ROLE OF LOCAL AND REGIONAL GROUNDWATER FLOWS IN CONTROLLING EROSION RATES

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Gullying has been studied in the Piracema basin, a tributary of Bananal river which drains toward the middle course of Paraíba do Sul river (boundary of São Paulo and Rio de Janeiro states). Most gullies developed along the topographic hollow axis of structurally-controlled amphitheater-like landforms, in connection with the expansion of the regional channel network (83%, for N=117), among which 52% are stabilized and 31% are active; the other 17% of observed cases developed in separately, along minor topographic hollows of the headwater zones. Gully extension is controlled by topographic aspects: gradient and hollow density within the amphitheater or above channel heads.

A typical case has been measured at Bela Vista amphitheater since 1982 showing an average retreat rate on the order of 1,300 m³/year. This gully progressed through the axis of a major topographic hollow, growing finger-tips toward the upper, minor hollow axis. The main trunk and its minor tips developed parallel to the underlying sub-vertical joints. Average monthly erosion rates tend to increase linearly with average monthly rainfall. One of the gully-tip is retreating faster and faster as it gets closer to the watershed divides.

Gully formation and network growth follow the "headward spring sapping" model stated by Dunne (1980,1990). Local, temporary subsurface flows exfiltrate at the base of thick, loose and highly permeable Late Quaternary fills; recharge is favored by vegetation-fauna-soil interactions near the surface: grass-roots and the network of pipes constructed by "Saúva" ants provide higher hydraulic conductivity within the dense-root zone of about 30 cm thick (1.26×10^{-4} cm/sec); at 30 cm and 60 cm it decreases to around 3.52×10^{-5} and 4.45×10^{-5} cm/sec, respectively. Once seepage erosion removes the sediment fill, retreat rates tend to accelerate due to the interference of the regional aquifer; as shown by a piezometer network. Gullying is progressing toward to the watershed divides and may cross it, reproducing the previous joint-controlled routes of the Pleistocene-Holocene transition.

DIFFERENTIAL RILL EROSION OF MUD ROCKS IN A TECTONIC ACTIVE AREA

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Rill erosion is studied in south-east and south western Taiwan respectively. Two types of mudrock sites were selected as they are made up of different types of mudrocks reflecting different sedimentary depositions and tectonic activities. The sites were instrumented to collect data that will be used to address selected issues related to slope retreat under a highly complex geomorphic environment, for the purposes of soil and water conservation. The methodology consists of a detailed field survey, continuous recording of site meteorological parameters, semi-automatic monitoring of the process and response parameters relevant to slope retreat, collection of photographic evidence, and laboratory analysis on the slope forming materials. The preliminary results obtained suggest that there is significant difference in rill development between the two sites. It is suggested that this is primarily due to the composition of the mudrock, the environmental conditions under which weathering occurs and the different processes of erosion. The development of gullies and rills in south-western Taiwan occur randomly and are dendritic in pattern. The Lichi area of south-eastern Taiwan demonstrates regular pattern of gully and rill development due in part to the degree of tectonic compression.

SOIL COVER AND SOIL EROSION IN AÇAILANDIA-MARANHÃO STATE (EASTERN AMAZONIA -BRAZIL)

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This paper regards the relationship between soil cover and the occurrence of erosional features, aiming to contribute towards the understanding of the environmental characterization of the area. During the last thirty years there has been an intense land degradation due to the forest clearing.

The methodology encompassed field work, where the linear erosional features were mapped and the soils were also identified. Soil samples were collected to be analysed in the laboratory. Photointerpretation was carried out using satellite images and aerial photographs, together with topographic maps (1:100,000 scale).

The study area is in the dissected landforms of the low Amazonian Plateaux Domain. The main rock types are: argillaceous sandstone (Itapecuru Formation) and white and pinkish red sandstone (Barreiras Formation). The climate presents a tropical regime with two distinct seasons: dry and wet seasons.

The classified soils are: Latosols (Red-Yellow and Yellow), Red-Yellow Podzolics, intergrades between those two types, Cambisols, Aluvium Soils and Hydromorphic Soils.

Regarding the occurrence of the mapped erosional features, they are found in all types of soils, except those situated on the floodplain and terraces. However, these features always occur in medium textured soils, tending to sandy soils.

Those soils with clayey and very clayey texture do not present linear erosional features. However, those soils are not dominant in the area. The total sandy content ranges between 40% and 87% being 64% the average. They regard the medium textured soils.

The fine sandy dominates the coarse fraction, which represents a higher erosional risk. Soil samples collected inside the gullies show a higher coarse fraction, which leads us to believe that the fines were transported to the gully outlet by the concentrated water flow, outlining the land degradation in the area.

GULLY MONITORING IN AÇAILANDIA - MARANHÃO STATE (BRAZIL)

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Açailândia was founded in the late 60s, beside Belem-Brasília Highway.

The city shows a high erosion risk, due to its sandy-loam soils, concentrated rainfall, irregular topography, deforestation and desorganized urbanization.

Due to those factors, several gullies have developed in the urban area. Therefore, a methodology was created to monitor the gully growth. Three gullies were selected and stakes were placed in the soil, approximately 10 metres from the gully border. The number of stakes depended on the size of the gully, being placed seventeen stakes in the largest gully, eight in a smaller one and seven in the smallest gully.

The monitoring period was between October-94 and August-95, that is, for eighteen months. The gully monitoring consisted of taking three measurements of the distance between each stake and the gully border. The use of a compass helps the measurements to be more accurate. Therefore, those measurements were taken in four epochs: October-94; January-95; May-95 and August-95.

A data-basis was created in order to plot diagrams for each gully. Through the diagrams it is possible to evaluate the speed and direction of the incision of each gully.

The created methodology for this research proved to be very useful to monitor gully growth because besides being very accurate, it is a relatively cheap way of investigating gully evolution.

Amongst the three gullies monitored, the one situated in the most urbanized area showed the quickest evolution, where some roads and houses were affected by the erosion process.

REGRESSIVE ALCOVES AND GULLY HEAD EXPANSION ON ALTERNATELY NON-COHESIVE TO COHESIVE MATERIALS

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Erosive features named "regressive alcoves" had been studied on an experimental field site, in which soil materials are predominantly non-cohesive. Frequently associated by the literature to seepage erosion, those erosive features proved to be mostly controlled by specific mechanisms associated to Hortonian overland flow. During the experiment, solid particles transported by overland flow and by subsurface flow were collected separately, after natural rain events. After each event, the total transported load was weighed and erosion rates estimated. The morphologic evolution of the erosive feature was followed in the field by the application of topographic techniques, adapted to the studied problem. Most of the gully head expansion was associated to the retreat of the "regressive alcoves". Although subsurface flow became of some importance during specific events, most of the erosion measured at the erosive features was associated to overland flow. Regressive alcoves are very common erosive features on tropical areas, and elsewhere. As one of the first observations needed to gully erosion control surveys is the precise identification of the points in which specific agents are important to gully erosion, the commonly accepted view regarding those erosive features, according to which regressive alcoves evolve as a consequence of seepage erosion, may lead, at least, to an expensive and unnecessary control design.

ORIGIN AND DYNAMICS OF EROSION PROCESSES IN THE URBAN AND PERIURBAN AREA OF MARINGÁ- PARANÁ

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The municipality of Maringá, situated in the north of Paraná, in spite of its clay soils, shows serious processes of erosion, generated by concentrated water drainage. The origin and evolution of some forms of erosion resulting from this situation are related to the use of the soil in urban and rural areas.

With the aim of determining the origin and the dynamics of the erosion in catchment areas, field surveys were carried out with measurements, along with description of the soil and collection of samples for sediment analysis.

The data obtained indicate that occupation of watersheds have been conditioned the concentration of pluvial drainage directed towards the headwaters, mainly in the urban area. Unsuitable urban drainage conditions have culminated in the formation of extensive gullies within the preservation areas of the original forest land (Interior Tropical Forest) in the city of Maringá. Both these areas and urban equipments are being seriously threatened by the progressive increase in the evolution of those gullies.

DISCONNECTED AND DISCONTINUOUS GULLY EROSION DEVELOPMENT ON VALLEY HEADS: THE "COLÔNIA QUERO-QUERO " STUDY CASE

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Discontinuous gullies are erosive features formed by independent incisions which may coalesce through time. Disconnected gullies are erosive features, identified frequently into valley heads, which incisions involve disconnected from the main drainage outlet. This work presents results of field experiments designed to investigate the main processes related to the development of a disconnected system of discontinuous gullies. The investigation followed three main axis:

- A) development of water flow from the source area;
- B) measurement of water flow into the gully incision;
- C) evolution of the gully system.

The flow from the source area was studied through tensiometric measurements, which enabled the study of saturated zones during a hydrologic year. Water flow into the gully incision was estimated by the use of an artesian rectangular spillway with thin walls. The evolution of the gully incision was followed by the use of topographic measurements through time and by estimating global erosion rates. The main inputs, related to natural precipitation, was analysed by pluviometric and pluviographic data. Due to a strong "El Niño" event during the monitoring year, erosion rates are stronger than previous rates estimated to the area. "Potholes" created at the interface between disconnected incisions, presented the highest erosion rates. Although the experiment design failed to furnish a precise account of all mechanisms effective to the development of the erosive system, we hypothesize that the conjoint action of several individual mechanisms promotes the integration of discontinuous gullies into a disconnected gully.

GULLY EROSION FOLLOWING INEFFICIENT EROSION CONTROL MEASURES

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Extremely severe gully erosion on arable, terraced red-yellow podsol at Pindorama (Sao Paulo State, Brazil) during a summer rainy period is described and analyzed. Research on soil erosion was begun in Sao Paulo State in the 1940s and as a result local knowledge exists for the construction of efficient terrace systems. In spite of the development of scientific expertise and promulgation of legislative norms, soil erosion control is still a great agricultural problem in this region.

The studied field is situated at 48° 55' W and 21° 23' S. The erosion prevention system, built before soybean cultivation, consisted of terrace-like steps aligned parallel to the contour lines, made by mechanical digging and accumulating the excavated materials to form 90-110 cm high banks with 90-110. The field was inconveniently divided, because terraces were 100 to 150 m apart, while common guidelines recommended no more than 20 to 25 m distance to optimize erosion control.

During the first intense austral summer storms, prior to crop emergence, a surface seal crust developed and rills were incised into the soil. Sediment was first trapped at the terrace bank convexity, but after 120 mm cumulative rainfall, since seedbed preparation, terrace overflow was observed. Later on terrace banks were incised, so that a continuous network, consisting of both, ephemeral and deep gullies was developed. Deep gullying was documented after 390 mm rainfall. A 15.3 ha slope representative of the upper hillslope environment was selected. Soil loss rate after 674 mm rainfall, i. e. 2 months since seedbed preparation, was as high as 49,6 tm/ha. Sediment production by gully erosion represented more than 95% of the total soil losses due to concentrated erosion.

GEOMORPHOLOGICAL AND PEDOLOGICAL CONTROLS ON GULLY AND RILL EROSION: PATY DO ALFERES MUNICIPALITY, SERRA DO MAR (RIO DE JANEIRO - BRAZIL)

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Paty do Alferes (RJ), localized in the reverse of "Serra do Mar", shows the intense erosional processes that are characteristic of the hilly compartments developed on weathered bedrock along Southeastern Brazilian Plateau. The erosional features are related to sheetwash and gullies/rills connected or disconnected to the drainage network, sometimes discontinuous. Agricultural activities and cattle breeding contribute to this situation, by using unsuitable techniques. Aiming to analyse the controls of channeled erosion processes, geomorphological and pedological studies were carried out in representative areas of the three different geomorphic domains recognized. Following the environmental evaluation procedure proposed by Moura et al. (1997), maps of topographic compartments, erosional processes and filling up or emptying conditions of valley bottoms were obtained for zero, first and second order drainage basins, using cartographic basis and aerial photographs at a scale of 1:20.000. These maps were combined with the soil map developed by CNPS/EMBRAPA at the same scale, and based on them were selected sites for sampling to characterize physical properties of surficial materials (0-15cm and 15-30 cm depth).

The results demonstrated that connected gullies occur on drainage basins with hollows and valley bottoms filled up by alluvial-colluvial deposits or on partially emptied ones, ratifying the regional mechanism of drainage lines re-incision presented by Moura et al. (1991; 1993) for Paraíba do Sul River middle valley. These re-incision on paleogully channels are largely controlled, in Paty do Alferes Municipality, by local base levels of the bedrock. The disconnected gullies or rills, on the other hand, are mainly related to very dissected slopes in step-like compartments, where gradient and litho-structural controls (joints/dikes) play a major role. In hilly compartments, however, this type of erosion is associated to pedological properties like high microporosity, high bulk density values and/or significant silt content on the topsoil. The observed relationships are important for the forecast of erosional channelled processes and for identification of critical areas/basins to agricultural and urban uses. *Supported by PADCT-FINEP, FUJB/UFRJ and CNPq

PREDICTION OF EPHEMERAL GULLY EROSION IN MEDITERRANEAN ENVIRONMENTS

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Soil erosion by water is considered to be one of the most important land degradation processes in Mediterranean Europe. Over the past decades most studies dealing with water erosion in this environment have mainly focussed on interrill (sheet) and rill erosion. However, recently collected data in the framework of the MEDALUS project (Mediterranean Desertification and Land Use) point to gully erosion as a very important sediment source: 50 to 80 % of total sediment produced in upland areas originates in ephemeral gullies. Given that gullies are effective links between upland areas and channels, gully erosion aggravates flooding problems and the silting up of reservoirs. Consequently, more attention should be given to the prediction of sediment production by ephemeral gully erosion under a range of environmental conditions. In order to predict soil losses by ephemeral gully erosion, the model EGEM (Ephemeral Gully Erosion Model) has been tested. EGEM has two major components, of which the hydrology component is a physical process model based on the runoff curve number. The erosion component uses the hydrology outputs to solve a combination of empirical relationships and physical process equations in order to compute the final width and depth of the ephemeral gully. An EGEM-input dataset for 86 ephemeral gullies was collected in cultivated lands in Southeast Spain and in both cultivated and abandoned lands in Southeast Portugal. A first analysis indicates that EGEM tends to underpredict soil losses by ephemeral gully erosion, probably because of the stony nature of most soils in the study area. However, an important input parameter for this model is total ephemeral gully length which is seldom available. Hence, threshold relationships between local slope gradient and drainage area for the beginning and ending of ephemeral gully trajectories have been established in a variety of Mediterranean environments in order to predict total ephemeral gully length. Despite the various physiographic conditions, landuses and storm characteristics in the studied areas, the results indicate a potential of the topographic threshold concept to predict the location of ephemeral gullies.

RECENT GULLY GROWTH AND THE RATE LAW

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Graf (1977)¹ proposed that after initiation, gullies approach a new equilibrium extent at an exponentially decreasing rate over time. Dendrochronological evidence was provided as field support for the rate law from 70 - 150 y old gullies in Colorado, and laboratory experiments on channel network growth have produced qualitatively similar results. The rate law is an intuitive and appealing concept that is included in many descriptions of geomorphic adjustment to change, however the age of many gullies precludes investigation of the processes responsible for gully growth and the physical meaning of the rate law.

Gully formation over the last 10 y in SE Australia has presented an opportunity to investigate the rate law in more detail. An exponential growth model fits the data well, with a half-life of only 0.7 - 3.5 y. Gullies have extended by only 10s of cm over the last 3 y of monitoring, and gully widening now dominates over headward growth. Closer examination and monitoring of erosion processes reveals a change in process dominance from overland flow during gully initiation to seepage erosion in the latter stages of network growth. It is proposed that the relative efficacy of these processes produces the rapid exponential decline in network growth observed. In some situations, initial rapid growth of gullies is a result of multiple points of scour which later merge by headcut retreat, rather than migration of a single headcut up through a valley.

¹ Graf, W. L. (1977) The rate law and fluvial geomorphology, *Am. J. Sci.* 277:178-191.

THE MAJOR TYPES OF GULLIES IN SÃO PAULO STATE, BRASIL

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In São Paulo State it can be distinguished two important types of gullies (linear erosion), related to the evolution of dynamic processes:

- a) in the west of São Paulo State (Planalto Ocidental), gullies just develop and spread out only in the rain season. This is due to the characteristics of the soils (sandy, too much permeable, and not so deep). After the remotion of the first horizons of the soil the underground water is easily reached and the erosion process is accentuated. During the drought season, water volume is low and the level of subsurface water goes down as well, so the piping action is inhibited and sediment yield is diminished. The evolution of erosion processes is seasonal and accelerated by human changes in the environment. The shape of the gullies are generally extended, branched out, like long stream courses.
- b) in the central part of the state (Depressão Periférica) soil profiles are generally very deep, inducing the development of large and deepy gullies. The subsurface water volume remains in the bed of the gully during whole year. The evolution process is continuous and slow. The gullies on head streams seem like amphitheatres.

Another import process which occurs in the eastern part of São Paulo state is related to landslides (Planalto Atlântico). These erosion processes are different from those in the west and central part of the state. They can be observed in high slopes, without vegetation cover or placed by slums or sometimes urban areas. Landslides generally occur during heavy rainfalls or after several days of continuous rain.

It is important to know the mechanisms of development of these processes in order to take the right measures to erosion prevention and control.

MONITORING AND CHARACTERIZATION OF DEEP GULLIES OF URBAN ZONES FROM ARAGUAÍNA CITY, TOCANTINS STATE, CENTRAL BRAZIL

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An erosional process from the urban area of Araguaína has caused social and environmental problems to the whole community. In turn, a high financial cost to the government and to the population in general was provided by these problems. Thus, in order to find out the behavior of these erosional processes and raise the corrective and the preventive proceedings, we have done a careful study, which consists in the monitoring of three areas where deep gullies been developing. Five others deep gullies were also observed, however, they do not present physical conditions to be monitored by the methodology adopted (pin, stake and profile method). Although such methodologies are most frequently used in the studies of fluvial marginal channels, we have done some adjustments in them to apply in our study. One of the deep gullies under study (Voçoroca Alfredo Nasser) has grows faster with the slope from point 01 retreat. In the deep gullies (Ravina Filadélfia), we have observed the same characteristic, however, the to move back is much more modest. The other deep gully (Voçoroca Murici) shows a different behavior. It remains stable since two year ago because the deviation of the pluvial waters flux. The corrective and preventive procedure that we have achieved from the collected data is the implementations of superficial drainage systems close the edges and inside of each erosion. Another alternative is the building of dam in the down direction in the erosion. In conclusion, we have noted that the better manner to prevent, control and correct the erosional process is planning the urbanization. With this procedure we can avoid the main agent, which is the influx of superficial water promoted by the pavementation of the streets and the lack of superficial drainage systems.

CHARACTERIZATION OF EROSION PROCESSES AT CACHOEIRA DO CAMPO, OURO PRETO, BRAZIL

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This work deals with growing erosion - deep gullies - located at Cachoeira do Campo District, Ouro Preto, State of Minas Gerais. Archean aged gnaisses and migmatites with granodioritic to tonalitic-thondjemitic composition occur at that region. Thick soil cover (15-20 m) becomes rare outcrops. The whole region is affected by erosive features which were reported in a map which represents their present evolution stage and spatial distribution. The erosion forms could be assembled in groups according to their morphology, similar processes and characteristics. Despite the general degradation of regional landscape it could be seen that only 14 out of 109 gullies reported are actually in activity, with groundwater displaying an important role, through piping phenomena. Superficial erosion processes affect the slopes and the front of several gullies but in a small influence range in most of them. The active gullies are located near Catete hills (south of the area) or bordering urban areas and suffer their influence. In the first case, as a hydrological reload zone, a major groundwater influence is expected on the environment but the lack of facilities and the unsuitable land use around the urban areas give rise to the reactivation of the erosion processes. Some of these forms represent typical situations and were subject to a more accurate study. The comparative study of 1949 and 1986 is aerial photographic sets permitted to evaluate the erosion growth and evolution rate. Retreats with more than a hundred meters were reported. This work was supported by FAPEMIG and developed at Departamento de Geologia, Escola de Minas, UFOP.

EPHEMERAL GULLY EROSION IN THE ORDENES BASIN OF A CORUÑA (SPAIN)

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Ephemeral gully erosion is a common type of water erosion in the loamy and silty loam soils developed over basin schists in the Ordenes Complex of A Coruña province (NW Spain).

The critical period for gully formation is any time when the soil surface remains bare and short intense rainfall events occurs.

Three case studies of severe gully erosion on small catchments and hillslopes (0.84 to 5.72 ha size) are presented. The first occurred in later spring, the second was caused by a strong summer thunderstorm and the third was promoted by early winter rainfall.

The objective of this study was to describe different types of ephemeral gullies and to determine their origin. Gullies formed within the field where runoff starts, gullies collecting the runoff from an upstream area and discontinuity gullies due to abrupt slope changes were identified.

The main cause of gully formation is the lack of any proper waterway for conveying water excess.

GRAVEL BEDS AND STONE-LINES ASSOCIATED WITH CENOZOIC SEDIMENTARY PROCESSES IN THE SOUTHEASTERN BRAZILIAN PLATEAU

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Stratigraphic studies of Cenozoic (Tertiary-Pleistocene) sedimentary successions in the depressed areas of the Paraíba do Sul River middle valley (Rio de Janeiro and São Paulo states) and Doce River middle valley (Minas Gerais state) shed light on the occurrence of gravel beds and stone-lines related to sedimentary processes. Morphostratigraphic and allostratigraphic approaches were used for their recognition and subdivision. The gravel beds and stone-lines are commonly associated with smooth convex interfluvial (paleo "rampa" complexes and/or re-featured fluvial terraces) that have undergone to topographic inversion. Most sedimentary successions are separated by gravel beds, which define erosive unconformities that subdivide the successions into allostratigraphic units composed of deeply weathered colluvial and alluvial deposits. Pedological studies show incomplete soil profiles truncated by the erosive unconformities. The gravel beds could be subdivided into three groups: a) clast-supported gravels (rounded to sub-rounded quartzose clasts, some lithics, moderately sorted, crudely stratified) related to ephemeral stream processes; b) matrix-supported gravels (sub-angular to sub-rounded quartzose clasts, sandy mud matrix, crudely stratified) related to gravity processes (debris flows); c) stone-lines (angular to sub-rounded quartzose clasts) interpreted as a rework of clast-supported gravel beds or possibly as lag deposits related to sheet flows that washed fines from previous debris flows deposits. The relationship between clast-supported gravel beds and stone-lines is evidenced by erosional features on the upper part of the gravel beds, where is observed a reshaping of the bed (concave-up to convex) and/or a lateral thinning (20-30cm to 5-10cm), that generates a stone-line. In cases where the allo-units directly overlie crystalline basement, the sedimentary origin of the gravel beds and stone-lines is supported by the clast roundness and the presence of lithic clasts, and by morphologic and stratigraphic relationships. Nevertheless, the high degree of weathering of the overlying deposits makes it very difficult to distinguish sedimentary features, which has led many authors to interpret them as autochthonous deposits.

EARLY ANTECEDENT TERM CONCEPTS OF PEDOGENIC STONE LINES

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The term 'stone-line' was defined in 1938 by C.F.S. Sharpe for a line of stones at the base of soils in the Appalachian piedmont of the southeastern U.S.A. However, antecedent synonyms, such as 'pebble band' and 'pebbly concentrate', existed long before 1938 in the midcontinental area of North America. Late in the 19th Century in Iowa and Illinois, for example, the 'pebble band' was observed to mark the top of the reddish B horizon of the Sangamon and other buried soils, the "ferretto zone" as well drained members were then called. But what early workers and later ones had actually described as the "ferretto" and its "pebbly concentrate" was only part of the Sangamon soil -- its stone enriched and oxidized uppermost B horizon. They failed, understandably, to recognize the Sangamon A and E horizons, which had been blurred and altered during and after burial via mixing (bioturbation), overprinting, and other pedodiagenic processes. They also failed to recognize that the stone-line is the lower part of a biomantle and a normal product of soil formation, mainly bioturbation. But such term-concepts as 'bioturbation' and 'biomantle' were not then available to these early workers, both having been introduced much later, respectively in 1952 and 1975. Consequently, owing to the unavailability of term-concepts to describe key pedogenic processes at the end of the last century, a simplistic and incorrect explanation was advanced that soils with stone-lines had been truncated by erosion before burial, and that stone-lines were thus geogenic, not pedogenic, in origin. This simple geogenic explanation was continued by mid-twentieth century soil scientists and geologists, for example Kellogg and Ruhe, a misconception, unfortunately, now firmly embedded in the concept of 'lithologic discontinuities'.

This early misconception is understandable for two principal and interrelated reasons: First, geological principles, not pedological ones, were employed in early soil investigations, a fact which links to the second reason; that many modern concepts and terms of pedogenesis and pedodiagenesis, such as overprinting ('welding'), pedoturbation (bioturbation, etc.), pedotranslocations, plus others which describe complex but real pedogenic processes are recent conceptual constructs that were not available to early researchers. The lesson here is that lack of terms which describe fundamental processes and which convey essential concepts in a science can retard that science. Truth then plays catch-up following later formulations of such constructs. But science, fortunately, is a self-correcting enterprise, and 'truth catch-up' invariably occurs.

STONE-LINES AND OXIC HORIZONS: BIOGENETIC ORGANISATIONS - SOIL FAUNA

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A pedologic cover on the Occidental Plateau in Botucatu, São Paulo State, was studied using a structural analysis approach. In upper landscape positions yellowish red to dark reddish brown (5YR hue) and sand-loamy to loam-sandy oxisols occur that exhibit a microaggregated structure. In lower landscape positions, soils (Nitisols) have higher clay levels, with redder colors (2.5 YR hues) and microaggregated structure at depth (oxic horizon) and a polyhedral one in subsurface (argillic horizon). The character of the soil toposequence largely reflects the underlying lithosequence: in higher landscape positions soil materials are sandy and are related to the underlying Cretaceous sandstones of the Bauru Group; in downvalley directions the sequence cuts Jurassic basalt of the Serra Geral Formation. The transition between sandstone and basalt is frequently marked by the presence of conglomerates rich in quartzite pebbles. The most important organizations in the pedological cover is presented in lateral distribution (scheme): the oxic horizon group with microaggregated structure; the sombric horizon; the stone-line and the charcoal fragments. Special attention was paid to transitions between the different pedological organisations.

Soils with oxic horizons that display microaggregate structures are distributed generally from upvalley to downvalley across the whole of the pedological cover. Microaggregated structure consists of oval packed microaggregates, with diameters that range from 50 - 500 microns. The usual explanation is that microaggregation is owed to physico-chemical processes, that is in stable union with certain forms of iron in connection with kaolinite. Evidence observed on the Botucatu Plateau, however, suggests a biological origin, mainly ant and termite activity.

The stone-line appears as a subsurface pebbly layer in the pedological cover. It has a wide distribution, not only in the research area but generally throughout the tropics. Though the composition of its component clasts is varied, weathering-resistant quartzite pebbles are rather common. Quartzite clasts prove stone-line allochthony where the subjacent substrate is basalt. On the matter of stone-line genesis, many authors favor the explanation that stone-lines are of sedimentary (erosional/depositional) origin, which would explain their wide spatial distribution. Considering pedological cover in Botucatu, however, that explanation cannot apply because the stone-line is present across the lithodependent lateral differentiation. The basalt related filiation grade of the stone-line overlaying materials increases from upstream to downstream. Considering the autochthony rising of the stone-line overlaying materials from upstream to downstream, the vertical translocation of soil material by ants and termites is the only mechanism that can explain stone-line genesis in this case.

The sombric horizon is a superficial paleo-horizon buried by soil materials vertically translocated by the soil fauna, mainly ants and termites. A quantitative estimate of the amount material translocated by soil fauna is presented. Abundant charcoal fragments are also present in the soil, and radiocarbon measurements on these allow us to estimate the rate of the bioturbation processes. On this basis, the amount of soil that has been biogenically translocated is estimated to be between 10.000 and 13.000 ton/ha. Charcoal that was subject to bioturbation and translocation has been dated at 4400 radiocarbon years BP. Rates of soil translocation in this soil range from 0.2 to 0.3 mm/year, or 2 to 3 cm/100 years, or 20-30 cm/1000 years. This suggests that stone-lines can form in the tropics by bioturbation rather quickly, and without invoking major climate or other environmental change.

ORIGIN OF A STONE LINE LATERITIC PROFILE IN CENTRAL BRAZIL

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Open pit mining and exploration drilling in a gold deposit in Central Brazil, about 400 km NW of Brasilia, has provided exposure of regolith materials for detailed observation and sampling. The area is dominated by a seasonally humid climate with annual precipitation of 1500 mm and "Cerrado" vegetation. The region has experienced a history of lateritic weathering and resulted in a landscape with plateau surfaces where lateritic profiles are generally preserved and gently undulating surfaces which may present stone line horizons down to two metres below the surface. Lateritization is thought to have developed during the aggradation phases of the Velhas geomorphological cycle in Lower Pleistocene (Braun, 1970). Incision of these surfaces has led to the degradation of the lateritic crust and formation of stone lines (Lecomte, 1988).

The weathering profile over the deposit shows a stone line horizon which is rich in quartz fragments and contains remnants of lateritic materials. Mass balance calculations, based on the geochemical immobility of Ti and Zr show absolute accumulation of Au, Fe and Si, indicating that quartz, lateritic materials and Au were added to the profile. Gold distribution in saprolite, stone line horizon and the top soil are very similar, showing that Au accumulation took place essentially downwards by chemical and mechanical processes (Porto & Hale, 1995). Lateritic materials have been mechanically worn but show geochemical signatures of the mineralized zone, indicating that they have accumulated in the stone line mechanically over the deposit area. Quartz fragments probably accumulated in a similar fashion but fragments directly derived from vein structures in the saprolite are also present.

The stone line is of a local origin and has formed by progressive downwards accumulation of materials into the residual soil and were only locally displaced laterally during the lowering of the land surface.

Abstracts **delivered at IAG 1999 Regional Conference on** **Geomorphology**

SESSION: Geomorphology Applied to Environmental Planning and Management

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INDUSTRIALIZATION IN THE MUNICIPALITIES OF PALMITAL AND PLATINA IN SÃO PAULO AND ITS ENVIRONMENTAL IMPACTS

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The decentralization of industry to the interior of the State of São Paulo - Brazil is being realized without the support of environmental planning which should assess the land capability to that economic activity. Although environmental concern, few municipalities have cartographic documentation about their environmental issues which make difficult the elaboration of Master Plans and Water Basin Committees actions. The research in course aims to analyze comparatively different degrees of environmental impacts due to industrialization in Palmital and Platina municipalities, situated in the Paranapanema River water basin. Deforestation, natural animal life extinction, agricultural and cattle raising impacts, use of toxicant product and its soil contamination and solid waste disposal are environmental problems already detected, those are aggravated by industrial activity. The industrial activities are located mainly in the urban centers and their sewage disposal is made in the surroundings water streams. Thus, the basins related to these streams were identified to proceed analysis and study the two urban sites. The elaboration of environmental diagnosis and prognosis by thematic maps, bibliographic and cartographic documentation analysis, field surveys, industrial spatial organization studies, in preferred water basins, provide useful technical and scientific material to support Municipalities in their Environmental Management duty.

GEOMORPHOLOGIC FEATURES AND TOURISM ATTRACTIONS IN CHAPADA DOS GUIMARÃES

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In South America, in the capital of Mato Grosso there is the Geodesic Mark of the South American Continent. This place is characterised by a big depression surrounded by plateaus. It has, in the transition between the plateau, Planalto dos Guimaraes, and the depression, Depressao Cuiabana, an area characterised by an expressive regional attraction, which has the possibility for the sustainable tourism. The approach of this communication is some relations among geomorphologic features (conserved plateau, dissected plateau, landings and columns relieves, landing in ravine crest and depression) and natural resources (climate, hydro, landscape, flora and fauna) which incorporated into the cultural patrimony (dancing, folklore, festivals, costumes and traditions) make dawn leisure and tourism areas in Chapada dos Guimarães, specifically in and around Parque Nacional de Chapada dos Guimarães. The work also discusses the necessity of determining a regional environment policy, with a mechanism capable of making the civil and environmental laws being factually fulfilled. A policy that recognises the natural risky areas and the potentiality for the usage, which also can define the tourism area in the context of eco-development and thus, respecting the local culture guaranteeing the life quality for the society.

EROSION MAP OF SÃO PAULO STATE, BRAZIL

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This paper presents the results of ten years of research activities related to rural and urban erosion in São Paulo State, located in the southeast of Brazil.

São Paulo has an area of approximately 250.000 km². Its tropical climate shows annual average rainfalls of 1.700mm. In Summer season, heavy rainfalls are responsible for the occurrence and development of gullies.

The Erosion Map of São Paulo State in 1:1.000.000 scale is the synthesis of the recent knowledge about erosion in the region. About 6.300 gully erosions were surveyed by aerial photos. They are specially located in the western part of the State, due to the characteristics of geology, relief and soil. Deforestation was the main factor responsible for the increase of the landscape alterations. During this study, the urban areas of all cities were also visited in order to recognize the gullies (causes of development and the damages to the environment). There are about 730 gullies mapped in urban areas.

Based on these information, the analyses have shown that 45% of the State territory are considered of high risk to erosion processes. This map is an instrument of erosion prevention, because it shows the main cities and drainage basins with serious erosion problems. It can be used to start specific studies of erosion control, recuperation and conservation of soil and water resources.

THE RELATION BETWEEN THE URBANIZATION PROCESS AND ENVIRONMENTAL DEGRADATION IN A SMALL WATERSHED: THE STUDY CASE OF CAMBUÍ-PUTINS, SÃO JOSÉ DOS CAMPOS, SÃO PAULO, BRAZIL

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This paper consists in analyzing the relationship between the urbanization and the degradation of the small watershed Cambuá-Putins, located at the city of São José dos Campos, state of São Paulo, during the period of 1977 to 1997. The study area presents some modifications due to an accelerated process of urbanization. The process of degradation is determined by the non organized urban expansion in the area of its spring, by the incompatibility of the uses related to the physical and environmental characteristics and by the throwing of domestic and industrial effluents (sewage) into the drainage without any treatment. It has the objective of evaluating the urban evolution and the environment degradation in the area of the small watershed. The methodological approach in the aspect of the small watershed used technical concepts of Landscape Ecology and the application of the techniques of Remote Sensing and Geoprocessing in the determination of Environmental Units, which compose the small watershed. Four environmental units were delimited according to the similarities of the physical - environmental conditions, the patterns of urbanization, the soil use and natural vegetation cover. The process of urbanization, degradation and alternative proposals of management specific to each unit were analyzed for each environment unit. The visual interpretation of the PAN/HRV spot images and the aerial photography produce a land use and vegetation map. Integrating the environmental units, land use map and the degradation map, the synthetic map was produced, which shows the urbanization process dynamic, relating the degradation intensity in each unit. An environmental zoning was proposed using those data. The Remote Sensing data and geoprocessing techniques showed to be very useful to the environmental analysis of this watershed.

RESTORING OF FUNCTIONAL LANDSCAPE IN LAGOON BORDER

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This project's aim is to contribute to the field of geomorphology applied to planning and environmental management, by restoring the functional landscape in the lagoon border of the coastal plain of Barra da Tijuca, Rio de Janeiro.

The project's proposition is to guarantee the functionality of the restinga environment, associated to the mangrove in the lake border area, concerning interactive dynamics, aiming at the sustainability of its ecosystems in the actual situation of pressure due to urban occupational expansion.

The understanding of this particular context, based on geo-morphological guidelines, interacting with other dynamic processes in issue, has provided conditions for the development of techniques and management procedures set on perspectives that are dynamic and suitable to an urban environment located in a coastal plain.

The outstanding aspect of the project is the restoring of this environmental structure comprised of restinga vegetation associated to the recovery of the area's geo-morphological body of sand, named lagoon barrier. With the recovery of the sand barrier, its original paleo-form was restored, which made it possible to produce the pedological basis necessary to the implantation of restinga species, by way of ecological management of the soil, associated with pioneer re-vegetation, both spontaneous and induced.

This work takes as its study object the phyto-geo-morphological analysis that builds parameters for conduct on phyto-pedological structuring. This study consists of an activity set into a major purpose, which is the identification of the existing interaction between the coastal plain of Jacarepaguá and the surrounding massif which form its amphitheatre, providing elements for suitable planning of the use of soil in this particular area.

MANAGEMENT OF ERODING ACCESS TRACKS AND FIREBREAKS IN NATIONAL PARKS

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Construction of access tracks in National Parks and other reserves in the south-west of Western Australia is an essential feature of Park management, as is the clearing of firebreaks. Yet they are also responsible for disrupting the vegetation in this region which is extremely rich in its unique flora and fauna (notably insects).

Construction of tracks and firebreaks appears to have been carried out with little or no appreciation of soil and slope characteristics and potential erodibility, or the effect of slope and stream sedimentation on terrestrial and aquatic flora and fauna. Firebreaks are constructed at right angles across the contour on steep slopes; side drains on tracks are not maintained and eventually surface runoff along the track either breaks through them or the drains become clogged with sediment. In both cases rilling develops on the tracks, sometimes to gully dimensions; sediment is deposited on the naturally vegetated slope, resulting in diminished species diversity; and pools in adjacent streams may be filled with sediment, destroying breeding sites.

The paper reports on the findings of a study carried out in a Western Australian National Park. Tracks and firebreaks were surveyed and the extent of erosion and sedimentation measured. Track erosion severity was related to the extent and nature of the area contributing runoff (both on- and off-track), considering slope, soil and vegetation characteristics. The use of the Park by visitors (using an on-site questionnaire survey) as well as current management methods were also assessed in order to evaluate the need for the access tracks.

An understanding of the erosion mechanisms and the pedo-geomorphic properties of the Park makes it possible to recommend several management measures. These fall into two groups: those relating to track closure or realignment (to avoid the most erosion-susceptible sites); and those relating to actual track design and maintenance.

ENVIRONMENTAL IMPACTS IN THE AGRICULTURAL AREAS OF THE GERICINÓ- MENDANHA MASSIF AND SURROUNDINGS

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The studied area, located in the West Side of Rio de Janeiro City, is represented by two main geomorphological features: the Mendanha Massif constituted predominately by Tertiary alkaline rocks igneous, and the Fluvial plain, represented by Quaternary sand-loamy sediments of fluvial origin. The soil classes found in the Massif are Latosol and Red-yellow Podzolic, and in the Fluvial Plain are Planossolo and Alluvial Soils. The climate is classified as the sub-humid dry megathermic. The Massif of Mendanha is an Ambiental Protected APA inserted, in the Atlantic forest Complex of the Rio de Janeiro county.

The two geomorphological domains were analyzed using the "Unit-soil" definition, representing the integration of the different environmental variables, in order to evaluate the impacts of the urbanization process in the degradation and reduction of the agricultural area. The Geographical Information System was used to improve this study. The maps of the Pedologic the Rio de Janeiro City / EMBRAPA, 1980" and the Planimetrical Base Maps of Rio de Janeiro City / IPLAN, 1997, in the scale of 1:50.000. were treated in the IDRISI System wide as version 2.0, SAGA/UFRJ and AutoCAD R14.

A reduction of 25,68% in the agricultural activity in the area was verified in the period between 1974 and 1998. Soils with high agricultural potential correspond 41,4% of the total area (30Km²), therefore just 11 Km² of the area is used for this propose. This is related to the expansion of the agricultural activity from the plain to the slope area, pushed by the accelerated urban growth, the soil lost, and the lack of investment and incentive for agriculture.

The problems of agricultural management and inadequate use of the soil aggravated, now, with the modifications in the occupation process, generating environmental transformations that are reflected rising the risk degree, both in the domain of the slopes, and in the fluvial plain.

ERODIBILITY OF THE HIDROGRAPHIC BASINS OF THE PEDRA BRANCA MASSIF - COUNTY OF RIO DE JANEIRO - RJ

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The tropical mountainous regions, as in the coastal massifs of Rio de Janeiro city, has been suffering, in last decades, intense mass movements and erosive process promoted by summer rains, generating serious social-environmental consequences. The Pedra Branca massif, the most important geomorphological form in the county, presents its hillsides with strong erosive potential, identified by present investigation, through morphological and morphometric analysis of its hydrographic basin associated to the dominant study of its litho-structural picture.

From the analysed micro-basin (71 in total), the ones located in the east and south watersheds (30 sub-basins) situated toward the lowland of Jacarepaguá, are distinguished as the ones with greater potential, from which the river Grande and Camorim basins are more important, with their valley structurally controlled, by means of faults systems with predominant directions N50-60E and N50-60W. The occurrence of intense erosion processes during the rains of february/1996 ratify such statement.

On the other hand, the north watershed of the massif looking toward hinterland lowland, presents draining deficiencies, resultant from identified low draining density values and low hydrographic density, and the west watershed presents its hydrographic basin with morphological and morphometric appearance similar to the first one, but with lower structural control.

The integrated analysis from such informations as compared with the dominant soil use and occupation characteristics will allow the identification of the most critical areas, as concerned to vulnerability to slides inside each basin, reinforcing the actions of the ambiental control organizations (ex. of GEORIO Foundation), as a preventive work against natural disasters.

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GEOMORPHOLOGICAL DOM-AINS OF THE RIO DE JANEIRO STATE, BRAZIL

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The Rio de Janeiro State presents a large set of relief compartments that reflects several types of landscapes and different forms of human intervention. The recognition and mapping of each relief compartment and the analysis of the acting erosion and depositional processes is important to evaluate environmental impacts and to bases purposes of territorial planning and management.

The Rio de Janeiro State could be presented synthetically on two morphostructural domains: the Atlantic Orogenic Belt and the Cenozoic Sedimentary Basins, and several morphosculptural domains, subordinated.

The first one composes metamorphic and igneous rocks of Neoproterozoic age affected by a extensional tectonic between the Jurassic and early Tertiary age, caused by the South Atlantic opening. This tectonic generates a sequence of normal faults that produced the coastal ranges and the high escarpments of the Serra do Mar and Mantiqueira.

The uplift of blocks resulting from this tectonic event sustained residual uplands such as the Bocaina and Varre-Sai Plateaus. Structural valleys were also produced, such as the Middle Paraíba do Sul Valley, that, sometimes, presents aligned ridges produced by lithological and structural controls. Next to the coastal plains occur low hilly terrains that were dissected until the Late Cenozoic in adjustment to the general base level.

The second one composes sedimentary rocks of Early Cenozoic age and sediments of Quaternary age. The sedimentary rocks were stored in continental basins of Eocene-Oligocene age, such as the Resende and Volta Redonda basins or next to the Ocean on the Northern State represented by the "Barreiras Formation". These terrains form a characteristic tablelands morphology. The sediments of the fluvial-marine lowlands and the coastal plains were generated by transgressive-regressive cycles during the Quaternary, that promoted the general drowning of the coastal relief characterized by bays, lagoons, beach ridges and isolated hills that marks the lowlands morphology.

FLOOD RISK STUDY AT THE MAIPO RIVER VALLEY IN PUENTE ALTO COUNTY, METROPOLITAN REGION, CHILE

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According with the determinations of the Metropolitan Plan of Urban Regulations (PRMS), scale 1:250.000, all the river bed of Maipo River that cross the Maipo County was classified how a sector with flood high risk.

But, because the scale, the PRMS means generalizations related to risk level terrain classifications. So local authorities, considering internal differences into the river bed and immediate fluvial terraces along it, ask for a investigation to determine the exact situation of this terrains.

A 1:2000 scale research was initiated to satisfy the information requeriments for the establishment of the potential and restrictions soil use ordinance.

Using topographic maps, aerial photographs and doing terrain surveys, joint with last decades statistical information of run off and the dimentions of the river bed (width and deep), the level of flood risk situation of the differents aluvial landforms was established, determining the restriction degrees to urban soil use or others meaning permanent settlement, and recommending some measures and alternatives.

THE INFLUENCE OF RELIEF IN HUMAN OCCUPANCY PROCESSES IN BELO HORIZONTE CITY, MINAS GERAIS, BRASIL

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In the year of 1897, the village of Curral D'El Rey became the new capital of the Minas Gerais State, and received the name of Belo Horizonte. This new city was planned and projected considering the existing landforms, which determined the way in which population occupied the space on the district. At the very beginning, it only occupied low hills with flat tops. Later on, due to urban growth, the relief determined this occupancy process. On the Southern and Eastern parts of the district, exists a predominance of high summits with ravined slopes and entrenched valleys, which belong to the so called "Quadrilátero Ferrífero". These characteristics limited the urban expansion. There is a different landscape on the Northern and Western parts of the city characterized by a range of low, top-flatted hills, and hills with entrenched valleys, belonging to the "Depressão Periférica do São Francisco", which favoured human occupancy. Nowadays, it is important to consider geology-geomorphological research to elaborate environmental planning studies taking into account human occupancy over a certain space, to avoid social problems, as well as problems related to environmental impact.

A SYNTHESIS OF THE GEOLOGIC/GEOMORPHOLOGIC EVOLUTION AND HUMAN MODIFICATIONS AT THE BERTIOGA, NORTH COAST OF SAO PAULO

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The present paper has with principal objective show the geologic/geomorphologic evolution of the coastal plain of the Bertioiga, coast of the State of São Paulo and estimate the transformations in its environment, as a result of the growing human occupation in its plain coast.

Bertioiga remained little impacted until approximately two decades behind. After the construction of the new roads to the north coast it started the process of devastation and pollution of its beaches, showing a modification of the environment, consequence of crescent occupation that has been occurring along of these roads and at the coast region itself.

With the use of the aerial photographs and existing maps it has been possible to make geomorphology and geology mapping, as well as evolution of the landscape use and occupation of four periods: 1962, 1977, 1986 and 1994. The information generated by the laboratory researches, in place visits and principal impacts verified, were registered in the synthesis map, entitled: "Integrated Synthesis Map".

On the geologic/geomorphologic maps are shown information of the litology and characteristics of the coastal relief.

In the synthesis map are shown information about the natural characteristics face to the human modifications. With the information available in the maps it is possible to make descriptions of the process in the Bertioiga's coastal region and the results on the coastal relief.

To make the maps it was used Geographical Information's Systems such as: AutoCAD, ARCVIEW, ARCINFO and IDRISI.

SOIL AS A GEOMORPHOLOGICAL UNIT IN THE SPATIAL ANALYSIS APPLIED TO URBAN PLANNING

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This research is based upon the soil study as an integrate environmental analysis regarded as the destination and use of Santa Cruz Government supported Region in order to grant the first environmental diagnosis at the western side of Rio de Janeiro.

The Soil Map of Rio de Janeiro Municipality (EMBRAPA, 1980) and The Planimetric Basis of Rio de Janeiro City (PLANRIO, 1977) were rasterized and directive vector added thus available only in analogue patterns at the scale of 1:50.000.

The Geographic Information System (GIS) was used to allow the spatial relationship among thematic geo-referenced areas, and Idrisi 2.0 for Windows was used for this implementation.

The environmental degradation and unbalance in such area is basically due to incompatible soil use.

In order to verify and define this soil usage a different soil map of urban occupation areas was developed as well as an industrial and agriculture chart with various soil differences with the need to have a better regulated and managed territory.

QUATERNARY EVOLUTION OF HEADWATERS IN DEFINITION OF POTENTIAL AREAS OF GULLY AND RILL EROSION BY GEOPROCESSING: BARRA MANSA COUNTY, RIO DE JANEIRO - BRAZIL

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This work presents the application of an environmental evaluation methodology based on headwaters dynamic evolution in hilly domains of Southeastern Brazilian Plateau (Moura et al., 1997) for definition of potential erosion areas and degradation conditions of tributary drainage basins of Paraíba do Sul River in Barra Mansa County (RJ), using geoprocessing techniques. Connected and disconnected gullies and rills were mapped on aerial photographs at a scale of 1:40,000, being distinguished as active or stabilized features, and also filling up or emptying valley bottoms in zero, first and second order drainage basins. They were crossed with topographic compartments, hipsometry, microbasins gradient, land use/vegetation cover and geology maps, all of them at a scale of 1:50,000, following the environmental analysis procedures proposed by SAGA-UFRJ. The environmental signatures obtained showed that connected gullies occur on drainage basins with hollows and valley bottoms filled up by alluvial-colluvial deposits (47.29% of active and 48.24% of stabilized gullies) or on partially emptied ones (45.5% of active and 39.87% of stabilized ones), mainly in second order basins (39.19% of active and 49.75% of stabilized features), ratifying an hierarquization control for drainage lines re-incision by gullies (Peixoto, 1993). Disconnected gullies/rills occur largely on emptied microbasins (80.74% of active and 84.67% of stabilized), being also common on filled up valley bottoms, being related to high gradients of side slopes and head slopes, high erodibility of surficial materials and/or land use. Cataclastic rocks and roads or urban buildings play an important role on generation of either connected or disconnected erosions. Based on these results and on gullies/rills dynamics knowledge, potential maps for connected and disconnected channeled erosions were developed, leading to recognition of main critical areas and/or drainage basins tributaries of Paraíba do Sul River concerning linear erosion, rivers silting and flooding. The results obtained testify the effectiveness of the methodologies integration proposed for definition of priority zones and strategic/caution actions in environmental planning and management.

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PHISICS AND NATURAL CONDITIONANTS OF MARUMBI SPECIAL AREA OF TOURIST INTERESTING - AEITM (SEA RANGE OF MOUNTAIN) - PARANA STATE) SUBSIDY OF ENVIRONMENTAL CHARACTERISTICS AND USE PLANNING

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The Marumbi Special Area of Tourist Interesting -AEITM, with 66.732 ha contain big part of Sea Range of Mountain in Parana State. With one relief compound of mound rounded, of convex hogback, generally elongate, in direction of diabasio dikes, reflecting the more resistance of lithologics components the erosion. The granite compact that, in occur of differentiation erosion, appear in geomorphology in relation the metamorphics rocks that the surround. The planning of area is more difficult for restrictions of physical ambience, economics disinterest and legislation restricted. The adopted methodology consist in application of one process of discrimination followed of one process of grouping of elements for determination of useful and homogenenent. In the AEITM, however the action of man is knowledge and almost always discordance with o environment, that again one extent reasonable of natural landscape of beauty great. The vegetation characteristics: content, texture and different colors, the our relation with the geomorphologycs formations of region, the dimension of trees associated the riches and exuberance of epiphytes, the typical aspects of mountain, the divers landscapes to contrasts with regional pattern, the distant vision of coastland, constitute one great landscape recourse. On this direction and knowledge the difficult in definition a level of field the geography location of limits of zones distinct, search to return the planning flexible, this form that environment variations the level micro, may be utilized the form the turned the more possible rational.

THE ENVIRONMENTAL SCENARIO OF THE UPPER WATERSHED OF THE MUTUCA CREEK (MINAS GERAIS)

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The environmental scenario of the watershed with its biotic and abiotic elements in the upper section of the Mutuca creek, southeastern of the metropolitan area of Belo Horizonte, MG, was mapped in a geoecological approach. The data were obtained from topographic charts, aerial photographs, TM Landsat image and field work. The GIS was used to the integration of the synthetic map. The high speed of the urban growth was observed on the steepness slopes resulting soil erosion processes and poor water quality of the Mutuca creek. There are mitigation actions to prevent impacts on the hydrologic pattern.

GEOMORPHOLOGICAL AND ENVIRONMENTAL IMPACTS OF LAND USE PATTERN CHANGE

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Most European landscapes have been transformed by millennia of human occupation. Agricultural landscapes include a series of man-made features established to reduce erosion (terraces, hedgerows, grassed waterways etc.). In hill regions of unconsolidated deposits and intensive farming the pattern of land use (the sizes and positions of fields, their boundaries) are of major significance both for soil and nature conservation.

The paper reports on investigations in Germany and Hungary, two countries where land use is in transformation. In Germany the unfavourable consequences of the formation of too large fields for mechanised farming are being eliminated and the renaturalisation of the drainage network has also begun. In Hungary the re-privatisation of the land of collective farms also provides an opportunity for the planning of an environmentally more acceptable rural land use pattern in the place of large-scale fields. During the implementation of the privatisation process, however, no landscape ecological considerations were observed and an extreme compartmentalisation of the landscape followed. Because of their shape (elongated stripes, often aligned downslope) and size (in many areas below 1 hectare), the cultivation of new plots does not harmonise with the historical pattern of the landscape as well as it is economically unprofitable. From certain viewpoints (eg. the application of chemicals), it may cause more damage than large-scale farming.

During the transition period in the test areas large tracts of land are left uncultivated and the unsettled land ownership discourages farmers from investing in the formation of an environmentally friendly pattern (plot sizes adjusted to topography and drainage, restoration of terraces and hedgerows etc.). Even the soil amelioration facilities (drain-pipes, irrigation canals, terraced slopes etc.) implemented by the former cooperative farms are falling to neglect or damaged. Forest stands have also been privatised and forest clearing increases the hazard of erosion in hills.

The increased erosion hazard and other environmental impacts underline author's conviction that in addition to proprietorial, economic, political, employment and other considerations, the success of design of land ownership pattern changes can also be evaluated on landscape ecological grounds.

WATER SOURCE EXPLOITATION LEGAL ASPECTS IN THE ENVIRONMENT MANAGEMENT

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The work accomplished had the intention of examining the actions related to the use of springs for population supply, inserted in the Brazilian environment legislation. It is a case study in one of the satellite cities of the Brasilia Federal district, where the urban growth has demanded a great effort from the institution responsible for supplying water in finding alternatives, considering the the region has small courses of water to face the growing demand. The Federal District, located in tablelands is, as matter of fact, a spring region, in despite of a considerable dry season during the winter. In a scenario pointed out as emergency, The "Fumal" was constructed to supply the city of Planaltina inside a protected ecological area, with a very restricted use, where the tributaries of The Amazon and Platina basins join together. The analysis concentrates in the conflicts derived between the need of the environmental protection in spring areas and a gap in the legislation related to the use of water resources. It also raises up a problem referring to the federal legislation inconsistencies that can not be applied at a local scale, which takes to dismiss the law.

GEOMORPHOLOGICAL APPROACH TO URBAN PLANNING: A CASE STUDY FROM GOUVEIA-MG, BRAZIL

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The objective of the study was the elaboration of a susceptibility map for urban planning purposes in Gouveia, a small town with about 10.000 inhabitants, localised in Minas Gerais State. The proximity of the farms to the city has not prevented the migration of people from the country. It has intensified with the increase of erosion and the decrease of productivity of the agricultural area. Inadequate land management and loss of vegetation cover are associated with the development of intensive erosion, especially gullies. Although having relatively good hydrological conditions, the city presents already indication of water supply shortage for human use purposes. Migration is taking place without the adoption of sound urban land-use planning policies. The surroundings of the city were analysed with the use of aerial-photographs (1:25.000) and sampling areas were selected on the basis of their possible priority for urban expansion. The collected data, contemplating geomorphologic, pedological and geotechnical aspects of the area, was analysed with the aim of determining the best sites from biophysical points of view for urban expansion. The analysis took also into account the intrinsic soil characteristics of the area and its suitability for urban use. By analysing thematic maps, field and laboratory data, such as water conditions, geotechnical behaviour of soil and its geomorpho-pedologic characteristics, it was possible to establish a consistent picture of the biophysical constraint of the area for urban use. The result was the generation of a final map, with the zonation of the surroundings of Gouveia in four areas, each of them with its own capability or limitation to urban land use.

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LANDSCAPE DYNAMICS AND SOCIAL AND ENVIRONMENTAL IMPACTS IN THE INFLUENCE AREA OF SEPETIBA'S PORT

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The transformation of Sepetiba's Port in a "Hub Port" has been motivating controversies one of which says respect to the environmental impacts in an area already intensely degraded.

This paper is focused in the area of influence of Sepetiba's Port that includes part of the basin of the Sepetiba's Bay. The basin was defined as the basic dynamic unit, whose functionality is fundamental to understand the dynamics of the integrands subsystems which are: Serra do Mar and Massifs of Pedra Branca e Gericinó-Mendanha, the coastal plain and the Sepetiba's Bay, located in the West Zone of the municipal district of Rio de Janeiro and Itaguaí.

For the study of coastal plain and of the massifs the methodology was based in the soil, used as a space unity of analysis since is correlates physical and social aspects.

By comparing this information, through GIS, use and occupation incompatibilities were determinated, as well as spatial and temporally evaluations of the urban-industrial expansion process, the degradation and loss of agricultural areas, the degradation and the extinction of ecosystems, and respective impacts on the quality of the local communities' life. The final results were the generation of maps of the soil, and its respective incompatibilities, serving as base for planning guidelines.

Starting from the verification of important changes in the coastal features the authors analysed models of evaluation and hydrodynamics in the bay, considering the need of understanding the connections between these processes and the human interference's in the subsystems of the Sepetiba's Bay. The results obtained are important to "trace" guidelines of environmental management and space reorganisation with the main objective of re-establishing the landscape, which was recently identified as an important fishing and tourist zone. In this way, this will guarantee the maintenance of the traditional economic activities of the local communities.

THE STUDY OF EROSIONAL PROCESSES BASED ON A WIDE-RANGING VULNERABILITY ANALYSIS - THE CASE OF THE SOUTHEASTSIDE OF MANAUS CITY, AMAZONAS STATE

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During the seventies and eighties, with the development of "Zona Franca" (duty free zone), the city of Manaus became the main regional migratory flux center. A sudden and deranged rhythm of the urban growth, culminates with an unsuitable areas for living, for example, steeped slopes, landslides and landscape erosion, lower-lying plains, forest park, etc., which in this way, promote new social and environmental problems. The bad land use and deforestation lead to changes on physical environmental (erosional processes), climate and tropical disease increase. The present study is paying particular attention to examining the erosional processes based on a wide-ranging vulnerability analysis of the southeastside of Manaus City.

The Vulnerability Map is - in agreement with Tricart's conception - the further identification of landscape stability units, based on the partial goals of Crepani et al. (1996). A vulnerability classification was accepted: stable, moderately stable, average stable/vulnerable, moderately vulnerable and vulnerable units. Forty erosional features were carry out into an Erosional Processes Distribution Map, mainly on antropic activity. Nevertheless, the evolutionary processes are strongly controlled by natural features of the rocks. The rill and gully erosions axes show northeast and northwest direction nearly concordant with the local lineaments. The Vulnerability and Erosional Processes Distribution maps together, congregates all forty erosional features related on vulnerable and moderately vulnerable units. In this sence, the task achieved proves by reasoning the effieience of the methodology applied. The identifing of vulnerable areas due to erosional processes becomes na important key to the urban planning. This work deals the racional planning of the studied region leading to a better quality of the urban environment for Manaus City.

DETERMINATION OF ENVIRONMENTAL SUSCEPTIBILITY AND POTENTIAL USE OF PUBLIC VISIT TRACKS IN THE CURUCUTU NUCLEUS OF THE STATE PARK OF SERRA DO MAR - BRAZILIAN SOUTHEAST

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This work assesses the environmental susceptibility in face of "Ecotourism" demand in the Curutu nucleus of the State Park of Serra do Mar, situated in the south of São Paulo City and north of the Escarpa and coast of the Itanhaém and Mongaguá. The theoretical and methodological foundations of the research are based on geomorphologic analysis of morphodynamic instability and stability of land, by identifying the capability and the degree of environmental fragility. It aims to reorganize land use from an "Environmental Zoning of Land Use Capability", on 1:50,000 scale setting up five categories of zones:

- 1- Permanent Conservation Zone;
- 2- Buffer Zone;
- 3 - Extensive Use Zone;
- 4 - Intensive Use Zone; 5 Recuperation Zone.

Furthermore, the research is assessing the six tracks of public visit from fields data and 1:10,000 scale thematic maps. The aim is deepening the analysis of environmental capability of the tracks and their surroundings, checking the proposed environmental zoning. The tracks are concentrated in areas of the Planalto Paulistano and Escarpa, with convex or angular top high mounts, where the soils are sandy over gneissic granites facilitate an intensive land dissecting. The slopes are over 20° a thresholds for landslides on the Serra do Mar. From the results, some guidelines for public use of the nucleus reorganization are being set, and one of them is the definition of rules for tracks visiting, aiming not to overcome the environmental capability identified or giving up another ones because of their high degree of fragility and morphodynamic instability. Moreover, the proposal of new tracks in sites more appropriated to the sustainable use of resources is being considered.

ENVIRONMENTAL PARAMETERS AS SUPPORT FOR URBAN PLANNING

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This work on applied geomorphology, part of a project being developed at the Department of Geography / University of São Paulo, represents a qualitative study based on the analysis of selected environmental parameters as support for urban planning. The area to be studied is part of an urban expansion vector in the city of Jundiaí, SP, Brazil. The recent urbanization process promoted in a short period of time the setting of severe erosion in some sectors of this area.

The main objective of this work is to define, based on a geomorphological approach, sectors prone mainly to linear erosion processes, which can be considered unsafe for urban land use. Other objectives refer to the development and preparation of cartographic documents to support the study, specially a morphologic map.

A first analysis of parameters such as morphology and declivity indicates that the urbanization of sectors which bear an association of concave forms with slope angles over 7 degrees may already accelerate morphogenetic processes such as linear erosion, specially if associated with the practice of removal of the vegetation cover. Sectors with slope angles over 17 degrees can be considered critical and should be avoided.

This work brings to discussion the use of geomorphology as an important tool in the decision taking process of urban planning.

THE CONTRIBUTION OF THE GEOMORPHOLOGY IN THE ELABORATION OF MASTERS PLANS IN THE PROTECT AREAS OF THE SAO PAULO'S COAST - BRAZILIAN SOUTH- EAST

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In São Paulo's State, in a systematic way, a few instruments of Environmental Planning in its Protect Areas, have been produced. Between 1996 and 1997 Masters Plans were elaborated for ten Protect Areas, through the "Projeto de Preservação da Mata Atlântica" (Atlantic Rain Forest Preservation Project), in the Coastal Province of the State. Such plans were elaborated being followed an unpublished methodology in São Paulo. The objective of this paper is to present the referring results of the researcher's contribution and risings in Geomorphology, while science that supplied important parameters for the elaboration of these plans, returned to the environmental management. The geomorphologic research was elaborated through of two levels of information:

- 1) the classification of the morphologic features diversity and associated morphodynamics processes;
- 2) the identification, starting from an analysis integrated with biological and socioeconomic factors, of the potentiality of habitats and occupation risk areas, for example, the subject ones the landslides and the susceptible to the overflow, typical processes of the slopes in the Serra do Mar.

The results already allowed a refinement of the proposals of Environmental Zoning existent for these areas, facilitating a rearrange of the inadequate land-use and adapting them to the support capacity of the environment, as well identifying the conflicts with the established environmental legislation. The vectors of human pressure were also appraised with relationship to the risk to the ecotonal areas, in places where the characteristics of the environment facilitated the regeneration of the significant vegetable covering, but that met under a degradation human use. This way, the Geomorphology's role is confirmed as fundamental science in applied works, as those that objectify to identify potentials and risks to the occupation in areas of complex compartmentation of the relief, as in the case here exposed.

TOURIST POTENTIAL AND QUALITY OF LIFE AS INDICATORS OF MAINTAINABLE DEVELOPMENT OF THE WEST ZONE WEST OF THE MUNICIPAL DISTRICT OF RIO DE JANEIRO

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The Massif of Gericinó - Mendanha, Environmental Conservation Unit, in agreement with the art. 2nd, letter "d" and "and" and the art. 18 of the law 6.938, of 31/08/81, shows a landscape of great scenic beauty with large areas densely forested and with rare biological species threatened with extinction.

Placed in the Zona Oeste of the Municipal district of Rio de Janeiro, the area is characterized predominantly by occupation of low income, exercising an influence in a resident concentrated population of approximately 2 million inhabitants.

In the last decades, this area has been suffering with the accelerated and not planned urbanization, where zones of agricultural vocation and of preservation are threatened by the settling of habitational groups, appearance and expansion of slums, and waste deposits.

These aspects urge, the need to evaluate the social-environmental relationships between the population and the Massif. As well as, to evidence the growing degradation of the forested area, through multitemporal analysis.

The area considered as direct influence from the Massif, was defined by the horizontal axis that ties the extreme east and west slopes, embracing the surrounding neighborhoods: Campo Grande, Sacred, Cosmos, Senator Vasconcelos, Bangu, Senator Camará, Priest Miguel and Realengo.

Crossing the map of use of the soil in different times, associated with the social environmental investigations, it was demonstrated an urgent need of an environmental administration plan in the Massif. Also the formulation of an ecological touristic plan, seeking the generation of business and lazer, in another program this will integrate the population adjacent to the Massif, generating a maintainable development for the area.

ON ANTHROPOGEOMORPHOLOGY

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Around 1970 the growth of environmental problems following technical progress, increasing public concern about the depletion of Earth Resources as well as the awareness of alterations on global processes and cycles led to a growing need for interdisciplinary research on assessment of anthropic impacts on natural systems.

On the one hand, at that time methodological issues were available but, on the other hand, they weren't taken on account. For example, the anthropic approach should take advantage of systems theory principles, detailed geomorphological cartography, several time-spatial scales, the frequency-magnitude approach, etc.

Analyses of literature on pure and applied geomorphology, and Brazilian studies on environmental planning, allow to conclude about general needs for recovering and employing basic principles and notions of the geomorphological approach to identify, measure, and predict the effects of human actions. The review of literature enable to propose a list of methodological procedures for the development of anthropogeomorphology according to the following basic items:

- #To look at human actions as geomorphological actions on terrestrial surface. It means that human activities promotes changes in form attributes, materials attributes and position, and processes rates, balances, and vectors;
- #To investigate patterns of human actions meaningful for morphodynamics;
- #To investigate cumulative and dynamic history of human interventions, starting from pre-disturbance stages;
- #To employ many supplementary time-space scales, especially large scales, i.e., 1:10000 and larger, or time intervals, i.e., days, hours, seconds...;
- #To employ and investigate new possibilities of detailed geomorphological cartography;
- #To take advantage of systems approach, and dynamic equilibrium theory;
- #To utilize thresholds notion and magnitude/frequency analysis;
- #To emphasize global/integrated analysis of natural systems (basins, slopes, etc.) to improve measurements and estimations of human intervention effects;
- #To take in account the particularities of morphoclimatic contexts, and
- #To amplify monitoring of rates, balances, and vectors of derivative processes.

COMPARATIVE STUDY OF GEOMORPHOLOGICAL MAPS APPLIED TO ENVIRONMENTAL ZONING

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The present work presents a proposed comparative study of three of geomorphological maps used in different projects of environmental zoning accomplished in Brazil starting from the decade of 90.

With the retaking of the process of regional planning of vast portions of the Brazilian territory located in the areas Center-West and North, the geomorphological studies has composed part of the ecological diagnoses, intermediary phase in this planning process, executing preponderant paper in the natural environmental units definition.

The conceptual base for such projects was given starting from the Environmental Diagnosis of Legal Amazônia that it contemplated a series of rising of the landscape, embracing geological, geomorphological and pedologic studies. In this work the first conceptual and methodological geomorphologic bases were thrown regarding the diagnosis to be implemented in the regional works of zoning.

GEOMORPHOLOGICAL MAPS IN ENVIRONMENT ZONING PROJECT

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The geomorphological researches based in mapping of the ways of relief, have seen increased in Brazilian territory. Its objectives are environment planning in different dimensions. Geomorphological maps and the others thematic maps have been used to create resume products like maps of fragility environment and maps of environment zoning.

The Conception is the system theory point if you consider that the way of terrestrial relief belongs to an interactive functional process and interdependents mutually among the other components of nature and human societies. The ways of terrestrial relief have their bases determined by the energy and flow matter which have been between components of nature. These ones are opposite and complete themselves. They get different physiognomy that appear in the earth surface thorough ways of relief, rocks, air, earth, vegetation, animals, and the men.

The methodology is based in Bertrand (1972), Sothawa (1968), Gerasimov (1946), Mecerjakov (1968), Tricart (1977), with changes by Ross (1990, 1992, 1994, 1995, and 1998). The ways of relief have functional stability or potential, upper instability. Then you have the taxonomy proposed by Ross (1990 and 1992) to creation of geomorphological map. Improving the production of unity environment map (Ross 1995 and 1998). These products have correlation with other plans of geographical informations. The getting the environment zoning. The greatest example which was applied was the basin Paraguay river-Brazil, in the Pantanal's Project with 396.000Km². This project was developed by scientists of University UFMS, UFMT, UFRGS, USP, UNESP, EMBRAPA and IBGE.

CONTRIBUTION OF GEOMORPHOLOGIC- PEDOLOGIC ATTRIBUTES ON ENVIRONMENTAL PLANNING IN REGION OF GUARATIBA

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This work is based on the study of soils as units of spatial analysis of the Administrative Region of Guaratiba, situated in West Zone-município Rio de Janeiro. The methodologic approach related to attributes and use/occupation served as assistance to diagnosis and reordainment of the region.

The close association of the soils with the geomorphologies, configurations has been proved, establishing the units environmental. Besides, the geomorphologic and pedologic attributes revealed strong influence in relation to human occupation and to definition and delimitation of the incompatibilities of spacial use.

During the ful.fil.ment of the study of these environmental conditions and the extension of the incompatible areas has been used software idrisi, revealing total the 21% of incompatibles areas, with 20 km² (15%) of rural areas and 7,93km² (5,8%) of incompatible urban areas in Guaratiba.

The areas of major incompatibilities are concentrated within the units of slopes and plains. The areas along slopes formed by granitic and gneissic rocks of the red yellow podzolic soils are vulnerables to landslides, where, as in the plains of fluvial-marin sediments, susceptible inundations, occur of gleys soils. The high index the incompatibles areas and the inadequate handling of the soils(rural and urban) they constitute the main degradation cause.

With base to the attributes of soils, it was possible to define and to delimit for the non occupates 4 classes for use: environmental preservation 25,8 km², agricultural 5,6 km², urbanized 11,0 km² and 5,0 km² for urban and agricultural use.

The methodological approach starting from the attributes of the soils, comes effective in the diagnosis of environmental degradation, it serves as a referencial to planning and space reordainment.

GEOMORPHOLOGICAL CARTOGRAPHY AS A BASE FOR NATURAL DISASTER PREVENTION: THE CASE OF THE EXTREME SOUTH OF SANTA CATARINA, BRAZIL

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In December of 1995 the extreme South of Santa Catarina State was affected by heavy rains concentrated on the valley's headwater (edge of the Brazilian South Plateau). The rainstorm meant a disaster to the local population, killing people, destroying houses and interrupting economical activities. With the objective of identifying areas potentially susceptible to similar natural events, the present study has been developed on the Rio da Pedra valley, located near the area affected in 1995. Both areas present the same morphological characteristics: high declivity on the headwaters (edge of the plateau) and plains formed by fluvial deposits in the form of alluvial fans. The study tries to identify, by the sediment forms found, plains areas subject to different kinds of floods, as well as to monitor the rain precipitation and the changes caused by them on the main fluvial channel. The preliminary data indicates that natural events of great extent, similar to the one occurred on the neighbour valleys in 1995, may have even more serious consequences in this valley: first because of the basin natural characteristics, that has area bigger than that of the neighbour valleys; second, by the human occupation which occurs mainly on the basin areas formed by fluvial deposits. In the sense, the detailed geomorphological cartography of the plain is a basic document for the territorial planning of the area, as well as for the elaboration of alert chart of the areas with possibility of being affected by great extent floods.

Abstracts **delivered at IAG 1999 Regional Conference on** **Geomorphology**

SESSION: Remote Sensing, Geoprocessing and Geomorphological Research

1. USING MIXTURE ANALYSIS FOR SOIL INFORMATION EXTRACTION FROM AN AVIRIS SCENE AT THE WALNUT GULCH EXPERIMENTAL WATERSHED - ARIZONA
2. MODELING THE DEPENDENCE OF GROUNDWATER FLOW ON TOPOGRAPHY AND LAND USE FOR FOUR 1,000 KM² CATCHMENTS IN RONDONIA, BRAZIL
3. RADARSAT-1/S2 AND TM LANDSAT DATA FUSION FOR RELIEF FEATURE ENHANCEMENT
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11. LAND USE CHANGE ANALYSIS BY LANDSAT-TM IMAGE: LAGOA SANTA AREA/ MINAS GERAIS - BRAZIL
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13. THE USE OF IMAGE PROCESSING TO ENHANCEMENT THE FEATURES RELATED WITH LANDSLIDE IN TM - LANDSAT DATA
14. LANDFORM UNITS DISCRIMINATION USING LANDSAT-TM AND ALGEBRA MAP
15. USING THE 3D ANALYST MODULE OF ARC-VIEW GIS TO IMPROVE THE VISUALIZATION OF EROSION AREAS IN SMALL URBAN WATERSHEDS
16. GEOMORPHOLOGY AND GEODIVERSITY

17. THE APPLICATION OF 3G-TECHNIQUE TO THE STUDY ON SUBMARINE STRATIFICATION IN SHENZHEN BEY, CHINA

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USING MIXTURE ANALYSIS FOR SOIL INFORMATION EXTRACTION FROM AN AVIRIS SCENE AT THE WALNUT GULCH EXPERIMENTAL WATERSHED - ARIZONA

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Spectral Mixture Analysis (SMA) has been used to extract qualitative and quantitative information about common features in an imagery at the subpixel level. At the Walnut Gulch Experimental Watershed (Arizona) this technique was used to produce the soil spectral map and quantify the fractions of each soil endmember on an image from the Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) sensor. SMA was applied on the base of image and reference endmembers in a geometrically corrected AVIRIS data. Atmospheric correction was performed by using the Atmospheric Removal Program (ATREM). SMA assumes that few features (endmembers) on the ground are responsible for the integrated radiance received by a sensor for a single pixel. SMA also assumes that the at the sensor spectral radiance represents a linear combination of the spectral response of each endmember multiplied by its individual fraction within a single pixel. Four image endmembers (McAllister and Stronghold soils, green vegetation, and shade) were needed to model AVIRIS data on the base of image endmembers. There was a general agreement between field observation and the delineation of the boundaries of McAllister and Stronghold soil series through the spectral map generated by SMA. Dark soils (Graham and Epitaph soil series) and shade fractions were separated only in the spatial context. A technique called target test was used to detect for the presence of reference endmembers on AVIRIS data. On the base six detected reference endmembers SMA was successfully applied for subset of image pixels.

MODELING THE DEPENDENCE OF GROUNDWATER FLOW ON TOPOGRAPHY AND LAND USE FOR FOUR 1,000 KM² CATCHMENTS IN RONDONIA, BRAZIL

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A major goal of current studies of Amazonian hydrology is to understand the impact of land use on streamflow. Analysis of hydrographs from four 1,000 km² basins in Rondonia shows that there is a strong correlation between the ruggedness of topography and the hydrologic response time of the river basin. This evidence supports the idea that before one can study how deforestation in a basin influences the streamflow, it is necessary to understand the antecedent factors that control the streamflow: land cover, topography, soil hydraulic properties, climate, and channel network topology. A physically based recharge model, groundwater model (MODFLOW), and river routing model (HEC-1), were employed to generate a modeled hydrograph which was validated against known basin hydrographs. MODFLOW was chosen as the central model because field observations and measurements show that most rainfall infiltrates to the aquifer before it reaches the channel by overland flow. MODFLOW was used to explore the hydrologic influence of topography on two forested basins representing extremes of rugged and smooth topography. After validating the model, a sensitivity analysis was performed to explore the influence of varying degrees of ruggedness in the basins. Based on this understanding of the importance of topography, two other basins with moderate degrees of deforestation and topography were modeled to understand how the effect of deforestation on the soil-water balance and groundwater recharge interacts with topography in affecting response time. Finally, the results were generalized to model the impact of various deforestation scenarios on the hydrology in these basins.

RADARSAT-1/S2 AND TM LANDSAT DATA FUSION FOR RELIEF FEATURE ENHANCEMENT

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Optical sensors have limited application in tropical humid forest regions because of the constant cloud cover, nadir viewing and shallow forest penetration capability. Orbital radar systems, however, are specially suited for studies in those regions because they are quite independent on the weather conditions and illumination; besides that, the side looking view increases their sensitivity to topography and surface roughness. In this paper the synergism between RADARSAT and TM LANDSAT data is explored for the enhancement of relief information. The study area is located in the State of Rondonia, Brazilian Amazon. This area was selected due to the flat terrain where the use of RADAR data is essential to the enhancement of the topographic texture and micro and macro surface topography. Optical and radar data fusion was performed by IHS transformation. The resulting product was submitted to photo-interpretation. The radar component of the integrated data was useful to map hills and crests in the region of large geological control. The drainage pattern showed organized and disorganized multidirectional shapes and unidirectional shapes. The micro topography and the low incidence angle provide by the S2 view responded for the modulation of the radar backscatter. TM contribution was related to the spectral differences between geomorphological units. The integration of optical and SAR data was essential to the extraction of relief information from the flat topography of the Amazon region.

GEOMORPHOLOGY OF THE REGION OF JAPARATINGA, ALAGOAS, BRAZIL

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The present work is a geomorphological study of the region of Japaratinga, situated on the northern coast of the State of Alagoas, northeastern Brazil. The area located within the Sergipe-Alagoas sedimentary basin; which constitutes a strip of sedimentary terrain that occurs along the coast of the States of Alagoas and Sergipe. The outcropping area of the basin is 13.000 km² and its submerse area comprises 20.000 km². The result of the investigation was the drawing of a semi detailed geomorphological map at 1: 50.000. Remote sensing and cartographic data were analyzed and processed by the GIS software SPRING.

GEOMORPHOLOGICAL PROCESSES MAPPING AS A CONTRIBUTION TO DECISION SUPPORT

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The present efforts to plan and develop the geographic area known as the Sepetiba Port Hinterland ("Retroporto de Sepetiba"), which comprises a great part of the Sepetiba Bay Coastal Plain, in the western part of the state of Rio de Janeiro, Brazil, bring into light the basic role played by Geomorphology upon the modern human occupation of a geographic area. This fact has been recognized by geographers since long ago, but the recent development of the technologies and methodologies of geoprocessing, remote sensing, together with investigations about landscape fragmentation and biodiversity, promoted a renewed and specific interest on geomorphologic classifications and related issues. It is possible to identify areas where dominant geomorphologic processes do act, and this identification may be translated into digital mapping. This procedure allows exhaustive investigation, and eventually the unexpected revealing, of topological relations occurring among the existing environmental (physical, biotic and socio-economic) conditions prevailing on a geographic area.

For the area of the Sepetiba Bay Coastal Plain, digital maps showing the territorial distribution of prevailing geomorphologic processes were successfully used as a basic support for environmental impact evaluation studies carried at the Laboratório de Geoprocessamento Aplicado of the Departamento de Geociencias of the Instituto de Agronomia of the Universidade Federal Rural do Rio de Janeiro.

Although requiring intensive attention to the relation processes x landforms, the identification of the territorial distribution of geomorphologic processes allows, through geoprocessing, the pointing out of simultaneous occurrences with other features. This may indicate causal relationships between the processes themselves and other relevant environmental characteristics. This direct indication of relationships is of special interest to decision support problems involving multidisciplinary research teams and financial resources administrators, particularly when concerning potential land uses and biodiversity investigations.

THE USE OF LANDSAT-TM IMAGE TO ANALYSE THE KARST SCENARIO AND LAND USE IN THE SÃO FRANCISCO RIVER VALLEY (NORTH MINAS GERAIS STATE-BRAZIL)

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In the studied scenario the change of cattle raising and traditional agriculture has substantially impacted the fundiary structure and also the karst.

This study was developed using digital Landsat-TM image (WRS 218/74-B) collected in July 1997. TM bands 3, 4 and 5 were chosen as input to digital analysis with the support of SITIM/INPE software. These Landsat data were submitted to a linear contrast stretch enhancement and HSI (Hue, saturation and intensity) transform to provide the best visual separation of the karstic relief units. The visual analysis of the spectral and spatial characteristics of the data, indicated that the results obtained with that approach were similar with the field data. The digital Landsat-TM image shows the different karst units and their different land use:

- I. COVERED KARST : <780m - Cretaceous Planation Surface, sandy soils, lateritic duricrust, savana, extensive cattle farms. 750 - 780m - South American Surface (Oligocene - Miocene), lateritic soils, duricrust, savana, pasture, semi intensive cattle farms.
- II. KARST: 615-750m - Fluvio-karst, doline landscape, karren field, restricted land use. 500-700m - Escalated escarpment, karren field, no land use.
- III. SÃO FRANCISCO KARST PLAIN: 440 - 500m - Dissolution dolines, irrigation systems (channels-river water; aerial-groundwater), agroindustrial settlements and semi intensive cattle farms.
- IV: SÃO FRANCISCO FLOOD PLAIN: 440 - 444m - Marginal dike, sand banks, marginal lakes, no land use.

*This research was supported by FAPEMIG (Fundação de Amparo à Pesquisa do Estado de Minas Gerais).

THE ADAPTILE USE OF KRIGING AS AN INFERENCEAL TECHNIQUE: THE USE OF SLOPE MODEL

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Kriging is a interpolation technique with a minimum error variance widely used as a reliable estimation method. Among the used forms, ordinary kriging is the most usual and has features as recognition of anisotropies, unbiasedness and the computation of the minimized estimation variance also know as the kriging variance. Such features are not all available in other interpolation methods, as polynomial triangulation, inverse of weighted distance, minimum curvature, polynomial regression, etc. That means, kriging provides a set of statistical tools for incorporating the spatial coordinates of the observation in data processing, allowing for description and modeling of spatial patterns, prediction at unsampled locations, and assessment of the uncertainty attached to these predictions.

But for the appropriate application of kriging spatial data information must be known. In the geostatistical literature, spatial patterns are usually described in terms of correlation and/or covariance between observation as a function of the separation distance. Semivariogram provides tools for detecting and quantifying the major scales of spatial variability.

The main purpose of this paper is call attention when using the kriging technique without previous evaluations of the spatial dependence of the data and the chosen example was altitude data. Altitude models are usefully in geological and geomorphological for evaluate spatial distribution of topographical potential erosion as well as deposition. Besides that, kriging can be used for modelling orientation slopes of fluvial units and also direction and capacity of sediment transport.

ENVIRONMENTAL RISK EVALUATION WITHIN AN URBAN AREA: THE EXAMPLE OF THE QUITITE VALLEY IN RIO DE JANEIRO

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Possibly, Rio can be placed within a group of urban areas which are constantly affected by natural catastrophes as a consequence of its dramatic climate variations, complex lithostratigraphy and structural geology, as well as constant human impact. The study area, as with many other locations in Rio de Janeiro, can be considered a good example of a deeply affected environment due to human/nature relationships.

This research concerns to the evaluation of environmental risks (e.g. landslides) in the Quitite Valley, west Rio. The methodology applied can be found in Xavier & Carvalho (1993). Geoprocessing was taken through the SAGA/UFRJ software. Various maps were produced and a few compiled (e.g. Vieira et al., 1997). Maps include those for vegetation, altimetry, geology, previous landslides locations and geomorphology. Subsequently, an environmental signature map was produced as a means of supporting a computerised planimetry which records natural and human characteristics that mostly control landslides phenomena in the valley.

All the obtained data served to a final evaluation of environmental risks in the Quitite Valley. A digital diagram was produced in order to present very low-, low-, medium-, medium/high-, high- and very high-risk areas for landslides in the valley. Such a diagram can give support to decision makers concerning the occupation of the valley in a way it causes minimum impact to the environment, among other applications.

References:

Vieira et al., 1997

Xavier & Carvalho, 1993

GIS BASED LANDSCAPE TOPOGRAPHIC UNITS MAPPING FOR TREE SPECIES POTENTIAL HABITAT MODELING

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This work presents a methodology for Landscape Topographic Units (LTU) mapping to be applied in tree species potential habitat modeling. LTU were determined as homogeneous units regarding Altitude, Aspect and Terrain Position. The study area is located in Vale do Paraíba Region in São Paulo State, Brazil, corresponding to IBGE Tremembé map sheet (1:50 000; SF-23-Y-B-V-4). Input data are 20m contour lines with VIPs and drainage network. Geographical analysis was conducted within ARC/INFO 7.0.2 environment. A triangular irregular network (TIN) was generated from the contour lines, using VIPs and drainage network as break lines. TIN was converted into gridded digital elevation model (DEM) from which Slope and Aspect maps were derived. DEM was stratified into 200 m Altitude classes, represented in the Altitude map (classes from 500 m to 1900 m). Aspect map was stratified into four classes centered at the cardinal directions. The procedure to generate Terrain Position map involved first the stratification of Slope map into two classes: $< 5^\circ$ and $\geq 5^\circ$. A 30 meters buffer was established along the drainage network which was then intersected to the stratified Slope map with the following rule: areas with $< 5^\circ$ slope and intersecting drainage buffer are attributed to Bottomland class; areas with $< 5^\circ$ slope which do not intersect drainage buffer are attributed to Hilltop class. Areas with $\geq 5^\circ$ slope were further stratified into terrain curvature classes by the application of CURVATURE function to the DEM, which discriminated Concave and Flat (curvature ≤ 0) and Convex (curvature > 0) classes. The intersection among Altitude, Aspect and Terrain Position maps yielded LTU map, which will be used as proxy information for habitat variables such as temperature and irradiance (Altitude and Aspect), soil hydric characteristics and erosive processes (Terrain Position) which are relevant for tree species colonization and survival.

APPLICABILITY OF REMOTE SENSING PRODUCTS TO THE PHYSIOGRAPHIC CHARACTERIZATION FOR SOIL MAPPING

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This study aims at evaluating the potential utilization of remote sensing products in soil survey. The visual interpretation of the superficial drainage patterns and relief characteristics of the Cardoso Island State Park is presented. The land stratification into homogeneous areas, called physiographic units, was performed through the interpretation of aerial photographs (scale of 1:25,000); the false color composite Landsat TM image (5, 4 and 3) scale 1:50,000; and radar image - GEMS 1,000 band X - semi controlled mosaic, scale 1:250,000. Each unit was characterized according to descriptive and quantitative elements of drainage and merely descriptive of relief. Through the interpretation elements the grouping analysis (Multivariable) was tested in the definition of the groups of physiographic units related to the different kinds of soil. From the analysis and discussion obtained the following conclusions can be drawn: the greatest contribution to the drawing of the superficial drainage network and the delimitation of homogeneous areas was given by the interpretation of aerial photographs followed by the Landsat TM images in relation to the radar images; stream frequency (among quantitative features), degree of control and angularity (among qualitative features) of the superficial drainage network as well as topographical position, relief kind and class were the most efficient variables in the separation of groups of physiographic units, both in the scale 1:25,000 and 1:50,000; the interpretation elements in the several remote sensing products as applied to the study of soils should not be analyzed separately but together; and the methodology used in the Cardoso Island is potentially valid in soil surveys at the level of semi-detail with the use of aerial photographs in the approximate scale of 1:25,000, at the level of recognition with orbital image in the scale of 1:50,000 and at a more general level with radar image in the scale of 1:250,000.

LAND USE CHANGE ANALYSIS BY LANDSAT-TM IMAGE: LAGOA SANTA AREA/ MINAS GERAIS - BRAZIL

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The land resource studies reported in this paper were developed in the Lagoa Santa Environmental Protection Area (APA Lagoa Santa) with the use of Remote Sensing and Geographic Information Systems. These technologies were applied for land use/cover mapping and monitoring. Two scenarios (1989 and 1997) were chosen for change detection analysis. The area of this study is located in the central region of Minas Gerais state and it was selected due to the presence of important Karstic relief (late Proterozoic calcareous rocks of Bambui group).

The land use/cover data were obtained from aerial photographs (1989) and digital Landsat-TM image (1997). These data were digitized and integrated with the support of a Geographic Information System (SITIM/SGI/INPE). A map of land use/cover change (1989 as 1997) was obtained. Due to the intensity of the antropic activities with the decrease of agriculture land use the temporal analysis has indicated that scenario of 1989 was more disturbed than 1997.

*This research was supported by FIP/PUC-Minas (Fundo de Incentivo a Pesquisa - Projeto 97/001 P)

THE APPLICATION OF REMOTE SENSING AND GEOPROCESSING TO THE GEOMORPHOLOGICAL STUDY OF NATAL AND PARNAMIRIM (RIO GRANDE DO NORTE)

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This study is part of an analysis of the influences of the antropic and physical environment, developed from Remote Sensing and Geoprocessing. With these techniques the results obtained by the overlapping of the geomorphological map with the slope angle map, the superficial composition and soil use, aiming to evaluate the dynamics of the erosive processes in an area exposed to antropic interferences, characterized by gentle slopes and sandy soils, which generally are mobilized by transport agents, especially wind, which has a considerable effect. This interpretation is based on field studies and laboratory anlysis of the collected materials in different areas, techniques that supported the mapping process and evaluation of elements that include the environmental system of the Natal/Parnamirim region, situated between the coordinates of 5° 53' 00" - 5° 55' 47" S and 35° 10' 53" - 35° 13' 30" W.

THE USE OF IMAGE PROCESSING TO ENHANCE THE FEATURES RELATED WITH LANDSLIDE IN TM - LANDSAT DATA

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Images processing such as linear contrast stretch, ration band, multiplication band and principal components transformation were used to enhance in TM - Landsat data features related to landslides occurrence as landslide scar, antropic features and relief features. The study was carried out among a sector of Serra do Mar in the city of Caraguatatuba (São Paulo, State, Brazil) using images obtained at January 1996.

The composition of band TM 473 RGB contributed most effectively to discriminate landslide scar differences. Antropic features and landslide scar features were highlighted by both ration band composition (5/7, 4/3, 4/1 RGB) and principal components composition (321 RGB), but only principal components composition could distinguished then. The multiplication band composition (5x4, 2x4, 7x4 RGB) contributed better to highlight relief features related to landslide as valley configuration and slope configuration.

The above techniques were supported by aerial photographs, topographic maps, thematic maps and field observation. The information obtained by these processing were integrated with MNT data and thematic data, generating the landslide hazard map.

LANDFORM UNITS DISCRIMINATION USING LANDSAT-TM AND ALGEBRA MAP

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The objective of this study is to prepare a geomorphological map of a section of the Rio Paraíba do Sul watershed in the surroundings of São José dos Campos City (São Paulo State) using remote sensing and GIS techniques. Color composite LANDSAT-TM images from both January (1987) and July (1988) were analyzed according image texture, shape, shadow and pattern characteristics. The landform units of this region were classified as denudational (hills and ridges) and depositional units (fluvial plains and terraces). The three types of interfluvial: flat, round and angular can be distinguished on these images. GIS techniques such as algebra map were applied to obtain two morphometric indices: interfluvial and relief amplitude. These parameters were calculated using the zonal operators implemented under the environment of the command language of the SPRING system (LEGAL). The result is a map of homogeneous landform units of the area under study.

USING THE 3D ANALYST MODULE OF ARC-VIEW GIS TO IMPROVE THE VISUALIZATION OF EROSION AREAS IN SMALL URBAN WATERSHEDS

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In the city of Jau - SP, an artificial lake was built in 1995. In 1996, it was filled by sediments removed of a small watershed site in the urban area by erosion in the slopes, occupied with agricultural and urban use. To evaluate and to identify the sediments source areas of the watershed, geographical information system techniques and methods were used.

A digital cartographic database was built at 1:10.000 scale, using topographic charts, soil maps and land use map. The maps were digitized and inputted in the ArcView 1.0 and Idrisi 2.0 GIS, to create a digital terrain model (DTM) and soil/land use raster maps. The DTM was built using the TIN (Triangulated Irregular Network), the most efficient model to design the landforms in digital form.

A cartographic model for erosion prediction was implemented in the GIS to obtain a watershed susceptibility erosion areas map. To improve the visualization of the susceptibility erosion map, it was joined to the watershed landforms and used the 3D Analyst Module of ArcView GIS. Applying that technique, it was possible to create a 3D landscape erosion map, that permits to the user to visualize the entire area in all directions possible.

GEOMORPHOLOGY AND GEODIVERSITY

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Landforms are the physical basis upon which life is organized at the Earth's surface. This affirmation includes the human use of the geographic space, but must not be used to ascertain any deterministic control upon human activities, which can even create artificial bases for its existence, such as the modern cities. This human capacity to control the environment does not preclude the fact that geomorphologic features identified and mapped for a specific area, taken as "homogeneous" or "isotropic" units, can be used as a logical platform to infer about the variability of other co-incident environmental characteristics.

It is reasonable to imagine that through a careful and exhaustive survey of the present-day locational co-incidences between landforms and vegetation covers, is possible to foresee, for instance, preferential paths for the creation of forest regeneration corridors along devastated areas. Thus, the natural locational associations of vegetation types and landforms registered today do teach us about how to select and conduct future environmental recovering measures.

The considerations above have their theoretic (and pragmatic) basis on the concept of GEODIVERSITY and its relationships with Geomorphology. GEODIVERSITY is the expression of the variability of environmental characteristics found in a geographic area. This robust concept can be made operational, i.e., turned into a rewarding environmental investigation procedure, through massive use of geoprocessing techniques upon geocoded databases containing multiple types of environmental information. In this regard, the geomorphologic classes identified for a geographic area can be used as a logical and physical territorial support upon which Geodiversity measurements can be obtained through geoprocessing. For each landform class identified at the database - postulated as an isotropic entity in terms of topographic shape, physical constitution and genetic processes - a planimetric rastering procedure can exhaustively generate a report on the occurrence of other relevant environmental characteristics, in the area covered by the selected landform. For this landform, it will be revealed how variable is the associated assemblage of other environmental characteristics such as soil, rock and vegetation types. Correlation measures and other comparative indicators can be derived from the results. A table containing some measurements of Geodiversity made on the Amazon Region is presented below, as an example of the operational possibilities of the mentioned concept.

Table 1 - Geodiversity indexes

Geomorphologic Map Classes	Specific Geodiversity					Geodiv. Multiple Geodiv. m (m*)	Geodiv. Weighted Multiple Divers. p (p*)
	Vegetation e (e*)	Soils e (e*)	Geology e (e*)	Lineation (Geology) e (e*)	Lineation (Geomorph.) e (e*)		
Isolated Inselberg (Ei5)	5 (11)	5 (4)	2 (3)	1 (4)	0 (4)	13 (10)	559,134 (2)
Grouped Inselberg (Egi5)	6 (10)	3 (6)	1 (4)	2 (3)	0 (4)	12 (11)	707,965 (1)
Flood Depositional Areas (Aai)	14 (6)	8 (2)	2 (3)	2 (3)	1 (3)	27 (6)	5,329 (10)
Pediplan Surface (Ep3)	23 (5)	9 (1)	4 (1)	5 (1)	0 (4)	41 (4)	4,201 (11)
Fluvial Terrace (Etf1)	6 (10)	3 (6)	2 (3)	0 (5)	2 (2)	13 (10)	15,142 (8)
Elevated Fluvial Terrace (Etf2)	14 (6)	5 (4)	2 (3)	0 (5)	2 (2)	23 (7)	17,065 (7)
Alluvial Plain (Apf)	38 (1)	8 (2)	3 (2)	3 (2)	3 (1)	55 (1)	2,156 (12)
Fluvio-lacustrine Plain (Apf)	10 (9)	5 (4)	2 (3)	0 (5)	0 (4)	17 (9)	21,548 (6)
Hills with very weak drainage incision and interfluvial areas with a span ≤ 250 m (c11)	5 (11)	4 (5)	2 (3)	0 (5)	0 (4)	11 (11)	12,816 (9)
Hills with very weak drainage incision and interfluvial areas with a span $>250 \leq 750$ m (c21)	13 (7)	5 (4)	1 (4)	3 (2)	1 (3)	23 (7)	34,987 (4)
Ridges with weak drainage incision and interfluvial areas with a span $>250 \leq 750$ m (k22)	2 (12)	2 (7)	1 (4)	2 (3)	0 (4)	7 (12)	77,008 (3)
Tablelands with very weak drainage incision and interfluvial areas with a span $>250 \leq 750$ m (t21) Tablelands with very weak drainage incision and interfluvial areas with a span $>250 \leq 750$ m (t21)	12 (8)	4 (5)	2 (3)	0 (5)	0 (4)	18 (8)	25,313 (5)
Tablelands with very weak drainage incision and interfluvial areas with a span $>750 \leq 1750$ m (t31)	27 (3)	8 (2)	3 (2)	3 (2)	2 (2)	43 (2)	2,030 (13)
Tablelands with very weak drainage incision and interfluvial areas with a span $>750 \leq 3750$ m (t41)	26 (4)	6 (3)	3 (2)	1 (4)	1 (3)	37 (5)	1,625 (14)
Tablelands with very weak drainage incision and interfluvial areas with a span $>3750 \leq 12750$ m (t51)	28 (2)	8 (2)	3 (2)	2 (3)	1 (3)	42 (3)	0,858 (15)

e = occurrences (counts)
 e^* = ranking of the class
 $m = \sum i e_i$
 m^* = ranking of the class
 $p = \sum i e_i / A$; A = area of the occurrence of the geomorphologic class (in this case divided by 1.000)
 p^* = ranking of the class

THE APPLICATION OF 3G-TECHNIQUE TO THE STUDY ON SUBMARINE STRATIFICATION IN SHENZHEN BEY, CHINA

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Shenzhen bay is a shallow water bay along east coast of Pearl estuary, China. For the sake of engineering, we need investigate the structure and spatial distribution of submarine stratification. This is a geomorphology and Quaternary research which supplies service for engineering within a small region, as well as a new experiment in spatial analysis of marine strata applying comprehensively the modern 3-G techniques ---GPS, GEOPULSE, GIS. The field work includes two aspects: one is the geomorphological and quaternary survey in Shenzhen bay and along its coast, the objective is to investigate the original geomorphological characteristics and the rough sketch of environmental evolution; the other is the survey in submarine stratification, mainly using GPS (Model 1008-586), GEOPULSE (5210A). Renting the steel hull ship that its load is 200 tons and light draught is 0.5m, we arranged the measuring line in NS and WE to begin our section measurement and investigation. After finishing the fieldwork, we give out the case explanation to seismic profile integrating with the comprehensive analysis of the geomorphological and quaternary survey along coast and in the sea. After checking and adjusting the drilling data in Shenzhen bay in several times, the whole profile was input to computer with the methods of manual collecting. The software we used is ARC/INFO. We got the spatial distribution of submarine stratification and all kinds of data through calculation. This paper will give emphasis on the application of new technology to the geomorphological and quaternary research within small region.

Abstracts **delivered at IAG 1999 Regional Conference on** **Geomorphology**

SESSION: Miscellaneous

1. A DIAGNOSTIC ABOUT EIAs-RIMAs DEVELOPMENT IN RIO DE JANEIRO STATE DURING THE 70'S , 80'S AND 90'S
2. MOPHOLOGY, ORIGIN AND DEVELOPMENT OF THE 'RECULEES' AND CANYONS OF THE KARSTIC PLATEAU OF ARCOS-PAINS, MINAS GERAIS STATE, BRAZIL
3. APPLICATIONS OF THE GEOGRAPHIC INFORMATION SYSTEM (SIG) IN ARCHAEOLOGICAL SITES OF THE CITY OF BREJO DA MADRE DE DEUS
4. ANALYSIS OF THE SPATIAL-TEMPORAL VARIATION OF EROSIVITY IN THE FEDERAL DISTRICT (DF) OF BRAZIL THROUGH ATMOSPHERIC CIRCULATION
5. NITROGEN IN SUBTROPICAL KARSTIC ENVIRONMENT
6. PODZOLIZATION AND SOIL ACIDIFICATION UNDER *Pinus caribaea* IN UBERLÂNDIA-UBERABA PLATEAU, MINAS GERAIS

A DIAGNOSTIC ABOUT EIAs-RIMAs DEVELOPMENT IN RIO DE JANEIRO STATE DURING THE 70'S , 80'S AND 90'S

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The men's search for improvement and confort has changed their "habitat" and simultaneously it has resulted in a increasing of pollution activities that damages, chiefly, the air and water quality which are necessary recourses for their healthy. Therefore, the urban center growth has been always followed by an increasing of environmental concern.

The foundation of water code (water law) in 1934 and forest code (forest law) in 1965 in Brazil are some of the most important matters for the continous search of legal instruments concerning the environmental control which precedes the EIAs RIMAs's compulsoriness.

The EIAs RIMAs appeared in 1977 in Rio de Janeiro State following the introduction of nuclear power station. The concern about the environment came out in Brazil as a result of environmental politics in the 70's, specifically in the USA and West Europe (with more emphasys in England, France, Germany and Sweden) when the Green Parties emerged.

This work concerns the EIAs RIMAs working out diagnostic in Rio de Janeiro State during the 70's, 80's and 90's. The work was basically developed through available data from each explored EIAs RIMAs and they were transformed in 4 tables in the following way:

Table 1: Place, Year, EIAs RIMAs type.

Table 2: Mainly subjects of each EIAs RIMAs.

Table 3: Responsable professionals by building up the EIAs RIMAs.

Table 4: Impacts and risks associated with the EIAs RIMAs.

Starting from the EIAs RIMAs analysis during the survey and tables, it was possible to realize that most executed EIAs RIMAs, until the present moment are not reaching the purposes established by the Law.

MORPHOLOGY, ORIGIN AND DEVELOPMENT OF THE 'RECULEES' AND CANYONS OF THE KARSTIC PLATEAU OF ARCOS-PAIS, MINAS GERAIS STATE, BRAZIL

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On the high basin of the Sao Francisco river in the state of Minas Gerais the Karstic Plateau of Arcos-Pais was characterized by geomorphological mapping, which develops over limestone of the Bambuí Group and can be recognized by the presence of long limestone massifs sectioned by 'reculees', which present themselves like flat-bottomed valleys, limited by abrupt escarpment with kilometeric extensions, and by canyons between 300-900m long and between 80-400m wide, which cross and divide the massifs.

The origin and developing dynamics of the 'reculees' and canyons can be comprehended by the understanding of their main conditioning factors, which are, the presence of dissoluble limestone placed over less soluble rocks with low permeability (marly and dolomitic rocks), which house different aquifers at the heights of 700 and 800m. The superior aquifer moves horizontally and vertically inside layers of stratified limestone, originating springs in the areas selected by the massif topography, especially in fracture zones, producing a more intense dissolution of the carbonatic layers on the points where these grow. The differentiated dissolution due to the karstic springs, produce valleys that retreat according to the hydric availability over a long period of time. During this process the valleys start to expand, widening and deepening on the bedrock with stratified limestone, and when they manage to break the little soluble layer of underlying dolomitic, they set in motion the vertical dissolution over layers of massive limestone and stratified one, positioned on the inferior portion of the carbonatic layers, reaching the level of the inferior aquifer, located at 700m. From this moment the 'reculees' deepen even more, being able to reach the massif base level, where blossom little soluble marl of the foot of the carbonatic layers, originating long and large 'reculees' which can evolve to canyons when they totally section the limestone massifs.

APPLICATIONS OF THE GEOGRAPHIC INFORMATION SYSTEM (SIG) IN ARCHAEOLOGICAL SITES OF THE CITY OF BREJO DA MADRE DE DEUS

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With the objective geographically to locate the situated archaeological sites in the city of the Brejo da Madre de Deus, Pernambuco state, the Geographic Information Systems (SIG) was applied, in an eminently archaeological work.

Based upon SC. 24-X-B-III Belo Jardim and SB. 24-Z-D-Vi Santa Cruz do Capibaribe, the city of the Brejo da Madre de Deus encloses an area of approximately 845 Km² of surface, being fit in the microregion of the Valley of Ipojuca, intermediate area between the humid bush and semi-arid hinterland.

Having knowledge of expressive amount of archaeological sites in this city, a bank of coordinate was confectioned of these sites, in order to get greater accuracy for the position and/or plotation. The tracking of the topographical points (sites) was assisted with the use of the Global Positioning System (GPS).

In each locative point, ambient informations on the proximity of the sites duly had been catalogued in specific fichas for a confrontation with the data observed after the plotation of sites in digitalized maps.

The analysis of this pilot area (Brejo da Madre de Deus), still that in small scale, it was complemented with images of satellite, digital letters and air photographs, searching to visualize the points located under some perspectives (archaeology, geology and vegetation).

Systemize this data set under an archaeological perspective, it was possible to raise information how much to the exploitation of the spaces used for prehistoric groups, identifying the areas of bigger anthropic activity in function of the available features in the identified ecological environments; visualized, in set, through digitalized maps.

ANALYSIS OF THE SPATIAL-TEMPORAL VARIATION OF EROSIVITY IN THE FEDERAL DISTRICT (DF) OF BRAZIL THROUGH ATMOSPHERIC CIRCULATION

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Erosivity represents the rains property to cause erosion. The parameters used to investigate it depend on the occurrence of rain which is directly linked to the atmospheric phenomena that originate and distribute it spatially. The objective of this work is to spatialize erosivity in the DF and to explain through dominant atmospheric circulation its spatial-temporal variation.

Precipitation data from 1979 to 1995 were used to calculate erosivity. Spatialization was obtained based on Kriging's geostatistic method. Since the region's climate presents an alternation of dry and rainy periods, the variation in erosivity (shown in the cartograms) was analysed during these two periods. The dislocation of air masses is the main element used to explain the weather patterns. In the Center-West region of Brazil the continental equatorial (mEc), tropical atlantic (mTa) and polar atlantic (mPa) air masses operate. Associated with these air masses are three systems of atmospheric circulation which determine the region's climate. The domination of these systems determines, in the summer, the dislocation of the cyclonal center (low pressure and high temperature) to dominate the Center-West region. The mEc, favoured by low pressure, and being hot and wet, carries rain and high temperatures to the region. The cartogram representative of this period shows high levels of erosivity. In the winter, when erosivity levels decline, the polar anticyclone migrates to the north and stops over the Center-West region.

Being a center of high pressure and low temperature, the polar anticyclone's presence provokes cold and dry weather. Thus, the erosivity in the DF, from a seasonal perspective, follows the rain pattern. From the spatial perspective, it presents an east-west tendency in erosivity growth. This tendency can be explained by the relief, which by interacting with the regional systems of atmospheric circulation acts over the region's climate determining rain distribution patterns.

NITROGEN IN SUBTROPICAL KARSTIC ENVIRONMENT

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This work is an attempt to evaluate the impact of the agrossystems on the quality of underground water reserves in a karstic hydrographic basin in the municipality of Colombo, part of the greater Curitiba, Parana state, Brazil.

The agrossystems system in this region revolves around intensive agriculture, geared toward commercial production, giving rise to the heavy usage of agrochemical which affect soil and water reserves. Among these chemicals, nitrogen was found to be the main pollutant, due to its mobility, and water solubility as nitrate, and consequent degradation of water quality. This because the karstic substratum presents dolines, faults and fissures that can lead to the entrance and circulation of pollutants in the aquifer.

This study was developed along two fundamental lines: (i) land vulnerability, as based on soil, landform and geological characteristics, and (ii) land occupation and use. It was defined and implemented weights to enable separation and ranking of different classes. This approach led to the generation of three maps: a map of land use and occupation, a map of land vulnerability, and an impact map which brings both types of factors together to predict areas of greater and lesser impacts.

The excess of nitrogen originating in horticulture was estimated, taking account the amounts used by farmers and the amounts extracted from crops produced over the course of a year. Nitrogen outflowing from rural households was also estimated.

Although, agriculture is the largest generator of nitrogen, water conservation in this area depends upon the ordering of activities and the disciplining of land occupation, avoiding land subdivision and urbanization.

PODZOLIZATION AND SOIL ACIDIFICATION UNDER *Pinus caribaea* IN UBERLÂNDIA-UBERABA PLATEAU, MINAS GERAIS

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The objective of this study was to identify a possible acidification and podzolization of the soils under plantation of *Pinus caribaea*. The study area is located in plateau Uberlândia-Uberaba, in the southeast portion of the municipal district of Uberlândia and north of the municipal district of Uberaba (MG). The area presents Latossolos (Oxisols) over basalts of the Serra Geral Formation (Jurassic) and sandstone of the Marília Formations (Meso-Cretaceous) and slopes < 1°. Surface soil samples (0-0.15 m) from three plots in CE and PI were sequentially extracted. Extracts and soil solution were analyzed for Al, Ca, Cu, Fe, K, Mg, Mn, Na, Si, and Zn concentrations, soil solution also for pH and electrical conductivity (EC). Total concentrations in soil solid phase ranged between 94,000-155,000 mg kg⁻¹ (Al), 29-39 (Ca), 21-31 (Cu), 44,000-61,000 (Fe), 91-141 (K), 21-29 (Mg), 28-57 (Mn), 73-94 (Na), and 13-21 (Zn). Whereas 27-83 % of total K, Ca, Mg, and Na concentrations were exchangeable, > 83 % of total Cu, Fe, Mn, Zn, and Al were bound in hardly plant-available forms. There were no significant differences in concentrations and partitioning between CE and PI. At the beginning of the rainy season (Oct. to Dec.), metal concentrations in soil solution were 2-5 times larger and more variable than between Dec. and Apr. because of the mineralization of organic matter which accumulated during the dry season. Metal concentrations in CE soil solution between Dec. and Apr. were extremely small at all depths (Al: not detected (n.d.)-3.26 µmol l⁻¹, Ca: 2.8-11.7, K: 0.9-6.7, Mg: 0.7-8.3, Mn: n.d.-0.14, Na: 5.5-40.1, Zn: 0.13-1.02). Up to 1.2 m soil depth, soil solution pH was significantly lower in PI than in CE. Concentrations of Ca, K, Mg, and Na were up to two times larger than in CE, those of Mn and Al 9 and 60 times, respectively. Whereas the soil solid phase did not show significant differences in metal concentrations and partitioning, the soil solution composition clearly indicated enhanced acidification in PI. This resulted in increased leaching of plant nutrients from the topsoil.