SESSIONS OF THE ACADEMIA BRASILEIRA DE CIÊNCIAS

SUMMARY OF COMMUNICATIONS

THEMES ON EARTH SCIENCES
Organizer:
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SEQUENCE STRATIGRAPHY OF THE PASSA DOIS GROUP IN THE SERRA DO ESPIGÃO, PARANÁ BASIN, BRAZIL*

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Presented by ANTONIO C. ROCHA-CAMPOS

The Passa Dois Group is divided into formations and members, representing variations of lithofacies separated by unconformities or correlative conformities.

The contact between the Passa Dois and Tubarão Groups is represented by a paraconformity, and the contact between the Passa Dois and São Bento Groups corresponds to a regional unconformity or correlative conformity.

Intracratonic basins differ physiographically from passive margin basins, for which the concepts of Sequence Stratigraphy were originally developed; so some adjustment has to be done for the application of the theory.

The 3rd order chronostratigraphic framework for the Passa Dois Group begins by offshore marine sedimentation of the Taquaral Member upon the coastal marine regressive sediments of the upper part of the Palermo Formation, through a conformable contact representing a transgressive surface. After this, a highstand phase prevails, bounded at its top by the maximum flooding surface, that is coincident with the lower conformable contact of the Assistência Member, which represents a new lowstand phase. Sea level rises again, through transgression, depositing the offshore sediments of the Serra Alta Formation. Deposition of the sediments of the Teresina Formation follows, suggesting a new lowstand phase with wave and tidal structures, than passes to the Serrinha Member of deeper waters with hummocky structures indicating a new highstand phase. A new lowstand phase occurs with well-sorted sandstones showing cross-stratification with medium to high angles, with clay drapes, suggesting the recurrence of tidal conditions, corresponding to the base of the Morro Pelado Member, that passes, by transition, to continental deposits, bounded at their top by a regional unconformity or a correlative conformity considered between the Passa Dois and the São Bento Groups, corresponding to a 2nd order sequence.

The thicknesses of each pair of units, deposited in shallower waters at its base and by deeper waters at its top, do not exceed 500 m. Considering a rate of deposition of the order of 1 m per each 10,000 years, they correspond to 3rd order sequences. The bounding surfaces that separate the sequences are of conformable type 2. Depositional systems characteristic of steeper slopes, or of floor basin fans or slope fans, that are common in sequences of type 1 are not observed. The duration of deposition of the related pairs varied from 1 to 10 M.a., well within the known duration of stages, which strengthens the hypothesis that they represent 3rd order sequences. — (*December 10, 1999*) .

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TESSELATED PAVEMENTS RELATED TO POST-DEPOSITIONAL STRUCTURES

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Tesselated pavements are curved or flat surfaces characterized by polyhedral geometric features (rectangular, pentagonal, hexagonal) of centimetric to metric size.

The genetic difference between desiccation cracks and tesselated structures occurs during lithification, when the sediment surface is exposed to weathering producing mosaic structuring. These structures are typically originated from initial cracking of previously lithified rocks. Simultaneous effects of weathering (climatic factors), fracturing and erosion on the denuded surfaces, impart the tesselated pattern.

Although the polygonal pattern is not penetrative, the edges of polygons may reach 20cm below the surface. Penetrative points may determine the spatial development of the tesselation in some cases.

Another characteristic of the tesselated structures is their occurrence on arched surfaces. These features comprise small oval mounds delimited by discontinuities similar to turtle or armadillo shells.

Well-known tesselated pavements occur in Australia (Branagan & Cains 1993). In Brazil the most conspicuous are located in sandstones of the Cabeças Formation in Parnaíba Basin (Sete Cidades National Park – PI). In an embryonic stage, however, they are common in several stratigraphic units from metasediments of the Precambrian Galho do Miguel (MG) and Morro do Chapéu (BA) formations and in sandstones of the late Paleozoic Itararé Group (Vila Velha State Park – PR) and silicificied pelites of the Permian Teresina Formation (SP). — (*December 10, 1999*) .

LATE PALEOZOIC GLACIAL SEDIMENTATION IN NORTHEASTERN BRAZIL: NEW RESULTS

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A glacial origin for late Paleozoic rocks of the Batinga Formation (Sergipe-Alagoas Basin) and Curituba Formation (Santa Brígida graben) are now well established on the basis of occurence of diamictites bearing faceted and striated clasts in places resting on glacially striated Precambrian pavement, intraformational soft-sediment, glacially and floating ice striated surfaces, and rhythmites containing dropstones. Additional studies have been performed on these rocks including facies analysis and regional compilation of orientation of glacial striae and paleocurrent, and of subsurface data. This allowed the delineation of a broad paleoenvironmental and paleogeographic picture of the glacial deposits. Facies distribution suggests a SE-NW change from more proximal glacial conditions in the Batinga Formation to distal (probably glacial marine) conditions in the Curituba Formation. Striae on pavements and surfaces are consistently oriented from SE-NW. Sense of movement of glacier cannot be clearly established. Local evidence, however, may indicate flow toward SE. Lithofacies and isopach maps depict a major depocenter of the Batinga Formation situated to the SE of the Igreja Nova dome, suggesting that this structure may have behaved as an elevated area in the late Paleozoic.

Preliminary paleomagnetic results indicate a mean magnetization direction of declination of approximately 185° and inclination of 43°, similar to the magnetization of other South American late Paleozoic formations. The magnetization of the Batinga sediments was acquired in a geomagnetic field of reversal polarity that was dominant during the Permo-Carboniferous (*Kiaman* superchron). The shallow inclination (about 43°) indicates that the studied area was located at a low latitude (about 25°S) during the acquisition of the magnetic remanence. — (*December 10, 1999*) .

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STRATIGRAPHIC FRAMEWORK OF RIO DO SUL AND RIO BONITO (TRIUNFO MEMBER) FORMATIONS IN THE HERCÍLIO RIVER VALLEY (SC), PARANÁ BASIN (EARLY PERMIAN)*

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The main targets of this work are the Rio do Sul (upper third of Itararé Group) and Rio Bonito (Triunfo Member) formations (Early Permian) in the Hercílio river valley, northern Santa Catarina.

The Rio do Sul Formation is formed by marine and glacial deposits (shales, rhythmites, sandstones and diamictites). The overlying Triunfo Member, basal unit of the Rio Bonito Formation, is made up of sandstones, shales and locally coals, originated as postglacial deltas.

To understand the temporal and spatial evolution of the Rio do Sul and Triunfo depositional systems sequencial facies analyses of surface and subsurface (cores and logs) sections and chronocorrelation of these sections, using sedimentary cycle concepts, was applied.

Twenty-one facies were recognized in the studied area and grouped into eight successions: glacial, deglacial, deltaic, fluvial, deep marine and shallow marine offshore, shoreface, and tempestite marker.

Morphologically, three continuous scarpments separated by gentle hill topographies were mapped, which can be connected to three major transgressive-regressive sedimentary cycles.

The first cycle records "deep" marine sedimentation, probably outer shelf, characterized at the base by varvic Lontras shale transgressing over glacial deposits of the Mafra Formation; it is followed by regressive thick-bedded turbidites. The second cycle has transgressive thin-bedded turbidites at its base overlying the first cycle deposits, and passing upwards into "regressive" glacial (diamictites, varvites, subglacial outwash channels, etc) and fluvio-deltaic deposits. The third cycle is different in the north and south: in the north interfingering occurs between marine, glaciomarine, deglacial, marine and deltaic deposits, showing a gradual passage from the Rio do Sul Formation to the Triunfo Member. In the south, a thick "transgressive" shallow marine system overlies the second cycle, and evolves to regressive deltaic deposits of the Triunfo Member; this initial Triunfo delta is transgressed by a tempestite marker.

The palynological content suggests a shallow marine to coastal depositional environment with strong continental influence during the Sakmarian and Artinskian stages of the Early Permian. — (*December 10, 1999*) .

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THE PARIPUEIRA EVAPORITIC INTERVAL OF MACEIO SUB-BASIN – SERGIPE/ALAGOAS BASIN*

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Presented by ANTONIO C. ROCHA-CAMPOS

Lower Cretaceous basins of the eastern Brazilian border are characterised by widespread evaporitic occurrences. In the Sergipe/Alagoas Basin, the Paripueira evaporites indicate the first, restricted marine incursions. Evaporites occur in the Cururipe, Maceió and Paripueira areas in the Alagoas region, corresponding to regional structural depressions. In the Maceió evaporitic Sub-Basin, Paripueira sediments are found at depths below 800m. The whole interval is characterised by thick halite deposits, including shale and carbonate interfingerings, and sandstone towards the base of the section. Strong facies changes between siliciclastic sediments and evaporites indicate successive drawdowns of the brine level. Differences in layer thickness in close well profiles (about 100m) suggest strong tectonic control. The absence of well-defined cycles does not permit internal correlation of saline deposits. Periods of low brine concentration are commonly rich in terrigenous or thin calcareous sediments. Halite predominates in the whole interval. It presents light and dark bands that display $\sim$ 4mm sized crystals. Light bands show absence of primary structures with fluid inclusions. Levels of cubic halite crystals, more than 5mm in size, common in a clay matrix, display displacive growth, probably related to sabkha processes. Under the microscope, halite crystals are subhedral, displaying partially dissolved borders and calcite, dolomite and quartz as solid inclusions. Halite also exhibits variable bromine contents (27 – 104ppm). High anoxic conditions lead to preservation of the organic matter, as shown by high TOC, higher than 13% in marls and shales. — (*December 10, 1999*) .

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ANISOTROPY OF MAGNETIC SUSCEPTIBILITY APPLIED TO DIAMICTITES OF THE RIO DO SUL FORMATION, PARANÁ BASIN: INITIAL RESULTS

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Massive diamictites interbedded with sandstones constitute the upper part of the Permo-Carboniferous Rio do Sul Formation (Itararé Group). These diamictites consist of dispersed centimeter to meter size clasts in a muddy to muddy-sandy matrix deposited in a subaqueous "rain-out" glaciogenic environment. They frequently have transitional contacts with crudely stratified diamictites. These facies probably formed as a result of downslope resedimentation in areas of the basin receiving fine-grained sediments from suspension and sandy turbidites. The fabric patterns of diamictites from Rio do Sul Formation have been studied through anisotropy of magnetic susceptibility. A subhorizontal to weakly imbricate magnetic planar fabric, corresponding to bedding plane, appears in whole samples. The magnetic lineation occurs dispersed on the bedding or has a faint alignment generally to NW or SE directions. This fabric pattern is attributed to settling of sediments into a weak current on basin floor. Five stations have a well defined N- to NW-trending magnetic lineation, suggestive of a post-depositional alignement process. These rocks have weak susceptibility magnitudes ($k < 0.2 \times 10^{-3}$ SI) and anisotropy degree. A strong paramagnetic contribution characterizes the hysteresis loop and no lattice transitions due to ferromagnetic fraction are observed in the susceptibility versus temperature variation diagrams. MEV investigations detected the presence of chlorite blades coating detrital grains or partially infilling the pore spaces. If these paramagnetic phyllosilicates controll the anisotropy of susceptibility, the magnetic fabric pattern of the diamictites has an important diagenetic contribution. — (*December 10, 1999*) .

LATE PALEOZOIC GLACIAL BOULDER PAVEMENTS FROM JUMIRIM, SP (ITARARÉ SUBGROUP): NEW EVIDENCE ON ORIGIN*

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Mapping and facies analysis of diamictites containing boulder pavements and associated rocks from the upper part of the Itararé Subgroup in Jumirim, SP, furnished additional evidence on the glacial paleoenvironmental context and origin of the clast concentrations.

Five facies associations have been mapped and interpreted in terms of their paleoenvironment. *Associations I and II* were formed mainly by the settling of muds from suspended sediments plumes derived from subglacial meltwater plus a variable contribution of debris from floating ice. Evidence of reworking of glaciogenic debris by bottom traction currents is also present; *Association III* represents a subaqueous clastic fan fed by meltwater currents; *Association IV* is a fluvio-deltaic subaqueous (or partly subaerial) outwash wedge that passes distally to a submarine fan associated with flows of glaciogenic debris; *Association V* includes a lower subglacial diamictite (lodgement tillite) resting on a glaciotectonized substratum, overlain by a possible meltout diamictite (meltout tillite).

Boulder pavements A and B occur respectively in the lower and upper diamictites of Association V. Environment of deposition of the lower diamictite implies in the formation of the boulder pavement during deposition of a subglacial till. Formation of the pavement may thus have been through processes related to lodgement. Interpretation of the upper diamictite as a subglacial meltout tillite and origin of boulder pavement B in this context are less clear. It is preliminary interpreted as a structure inherited from the basal transport zone of ice.

Rocks studied record the permanence of glacial influence during deposition of the uppermost beds of the Itararé Subgroup in northern Paraná Basin. The general environmental setting is interpreted as a subaqueous (possibly marine) basin marginally affected by a late advance and retreat of the Kaokoveld glacial lobe. — (*December 10, 1999*) .

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OCCURRENCES OF EVAPORITES IN THE IRATI SUBGROUP (LATE PERMIAN, PARANÁ BASIN)

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Evaporite deposits in the Paraná Basin are unusual and of limited occurrence. The Morro do Alto (lower) and Ipeúna (upper) members of the Assistência Formation (Irati Subgroup) include the most expressive evidence for Late Permian evaporitic sedimentation in this syneclise.

During the regressive event after sedimentation of the Taquaral Formation, the area north of the Ponta Grossa Arc (in São Paulo State) became a hypersaline residual sea, leading to calcium sulfate precipitation in a restricted

stagnant paleoenvironment and dry climate.

The Taquaral-Assistência boundary is distinguished by the transition from non-bituminous shale to organic-rich bituminous shale. At this contact are evaporitic breccias that deform the basal beds of the overlying Assistência Formation.

In the upper part of the Bairrinho bed (Ipeúna Member, Assistência Formation), northeastern São Paulo, evaporite was deposited in another short transgressive-regressive cycle. Later this bed was deformed by salt mini-domes which were later replaced by chalcedony.

In the northern portion of the Paraná Basin (southern Goiás State), between the Assistência and Corumbataí formations, there are partially silicified strata with mesosaurid bones. This contact is marked by silicified mini-domes, horizons with radial-fibrous crystals and breccias like those found in the evaporitic deposits of São Paulo State. These silicified rocks occur above the last bituminous shale, thus denoting a third evaporitic acumulation at the top of the Irati Subgroup. — (*December 10, 1999*) .

DIAMICTITE FACIES OF THE ITARARÉ SUBGROUP (LATE PALEOZOIC), IN THE SOUTHERN PARANÁ BASIN, BRAZIL*

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Diagnostic features of glacigenic deposits, both in the continental and marine environments, have been extensively discussed in the last decades.

A special facies classification of these rocks similar to that used by Canuto (1993) with some improvements, is here proposed, with practical approaches to field applications, based on lithology, texture, structure, clast orientation, color, geometry, lateral extension and, in some cases, presence of ichnofossils, microfossils and palinologic content.

Compact massive diamictite facies. This facies is composed by compacted massive diamictite, with shearing at the base. It occurs in the form of discontinuous bodies plastered in irregularities of the substratum, whose surface is flat, polished and estriated, with eventual "crescentic marks". The substratum, close to the contact, also reveals to have been sheared. It corresponds to the lodgement tillite. *Non-compact, massive diamictite facies.* It is a massive tillite, formed from the slow melting of stagnated ice masses. *Tabular diamictite facies.* It is composed of tabular, massive diamictite, formed by cohesive debris flows, having folded and faulted sandstone layers, which may be sheared, and disrupted, sometimes forming "sandstone balls", with clasts generaly without orientation. The lower contact is sharp, and the upper can be transitional to fine clastics. *Lenticular diamictite facies.* This facies is formed by channelized massive diamictite, deposited by cohesive debris flows. Its characteristics are similar to those of the tabular diamictite facies, differing by its geometry amalgamated and stacked channels, associated with the movement of lenticular channelized lobes tens of meters thick as a whole. The lower contact is sharp, and the upper can be transitional to fine clastics. Clasts may be oriented parallel to the bedding. *Deformed interbedded sandstone and diamictite facies.* It occurs as extensive tabular bodies, with metric thickness, of intercalated deformed diamictite and sandstone, with beds showing slump folds and faults, sometimes forming a chaotic mixture. It is interpreted as formed by gravitational flows of glaciogenic sediments, deposited at the margins of a water body, perhaps marine, and covered by shoreface sandstones. *Laminated clast rich diamictite facies.* Laminae are piled up with obscure contacts, or with suspension deposits. Bodies are up to tens of meters thick and were deposited by dense flows, intermediate between debris flows and turbidites. This facies differs from the debris flows by being turbulent flows which erode the substrate. *Laminated diamictite with lenses of massive diamictite facies.* Lamination is given by subparallels discontinuities or joints, without associated textural variation, eventually showing clast orientation. Lamination is undulate and includes lenticular, elongated bodies of massive diamictite. The diamictite is interpreted as formed by gravitational sedimentary flows. — (*December 10, 1999*) .

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THE INVERSION OF THE SÃO JOSÉ DO ITABORAÍ PALEOCENE BASIN (RJ) IN A STRIKE-SLIP REGIME*

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Drilling profiles from Companhia Nacional de Cimento Portland (CNPC) in the São José do Itaboraí Basin show separate domains with different contents of CaCO3 ($> 60\%, 30 - 60\%$ and $< 30\%$). This suggests that the basement contour of the basin was previously defined by CNPC on an economic basis, excluding the basal and peripheral layers with CaCO3 content $< 30\%$. This reinterpretation reveals a different basement contour for the basin, especially in its western portion where it becomes 50% larger. To the south, the limit of the basin is the ENE São José Fault, which has a dextral offset coincident with the NW Transverse Fault. To the north, the new limit of the basin is defined by *en echelon* segments parallel to the São José Fault, which is offset by NW structures parallel to the Transverse Fault. One of these structures shows slickensides with low rake striations probably generated by a strike-slip regime. The folds and reverse faults parallel to the São José Fault (Rodrigues Francisco & Cunha 1978, An. Acad. Bras. Ci., **50:** 381-416) reveal a basin inversion. The horizontal calcareous travertine veins that crosscut the vertical banded travertine layers and the gneissic basement near the São José Fault indicate that this inversion was, at least partially, synchronous with the hydrothermal activity in the basin. The basin inversion was associated with a counter-clockwise rotation of $\sigma 1$, from NE to NNW. The trace of the São José Fault suggests that this inversion was related to a change from a releasing to a restraining band in a sinistral strike-slip regime. Further, in the Pleistocene, the basin was affected by additional NW compression. — (*December 10, 1999*) .

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PALEOMAGNETISM OF CAACUPÉ AND ITACURUBÍ GROUPS, WESTERN BORDER OF PARANÁ BASIN, PARAGUAI

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The Silurian-Ordovician sequence, west of Paraná Basin is represented by the Caacupé Group (Paraguari, Cerro Jhú and Tobatí formations) and the Itacurubí Group (Eusébio Ayala, Vargas Penã and Cariy formations). This sequence is composed of basal conglomerate followed by continental/ marine sandstones, glacial diamictites, transgressive marine shales and regressive marine sandstones. The succession corresponds to a great transgressive-regressive cycle.

Two main components of magnetization, A (Dec= $348,9^\circ$ Inc= -42.9° N= 19, $\alpha_{95} = 11.5^\circ$ k= 7) and B (Dec= $163,2^\circ$ Inc= 48.6° N= 7, $\alpha_{95} = 9.9^\circ$ k= 22) were identified by means of paleomagnetic analyses and rock magnetic studies. These two components seem to characterize a dipolar geomagnetic field. The paleomagnetic pole based on both directions is located at 79°S 22°E (N= 26, $\alpha_{95} = 4.9^\circ$). This pole is close to the geographic pole and to South American Mesozoic paleomagnetic poles suggesting a possible remagnetization during Permo-Triassic or Cretaceous times. This remagnetization could be due to the thermal effects imparted by the Mesozoic magmatic events.

On the other hand, the two directions of magnetization are similar to those found for the Lipeón formation (Subandean Silurian sediments, NW Argentina) and the Serra Grande, Pimenteiras and Cabeças formations (Parnaíba Basin, Brasil), suggesting that the magnetization of the Caacupé Group was acquired during the Lower Paleozoic at latitudes as low as the present ones. — (*December 10, 1999*) .

STROMATOLITES IN THE MESOPROTEROZOIC ITAIACOCA GROUP (SE BRAZIL): PALEOENVIRONMENTAL INFERENCES AND COMPARISONS WITH OTHER SIMILAR FORMS

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Stromatolites have long been used as paleoenvironmental markers and for correlation within and among diverse Proterozoic basins. Coniform stromatolites of the Mesoproterozoic volcanosedimentary Itaiacoca Group in the Ribeira Belt of southeast Brazil form two types of bioherms south of Itapeva (São Paulo), one tabular and widespread, and the other lenticular and isolated. In both cases the predominance of *Conophyton* together with the rarity of other forms and with the absence of such shallow-water sedimentological indicators as microunconformities, stromatolitic intraclasts, and crinate strat-

iform stromatolites suggests a *relatively* deep depositional setting, below fairweather wave base. Morphological differences between the stromatolites apparently reflect differing degrees of luminosity in these two settings. In the more widespread bioherm, the composition (dolomite minimally contaminated by siliciclastics), larger diameters, and frequent lateral coalescence of the columns may all have been favored by relatively well lit, clear, possibly shallower waters. In the isolated bioherm, the generally narrower width and rare lateral coalescence of the stromatolites, plus the abundance of impurities in these calcitic limestones and the very lenticularity of the bioherm, suggest predominantly vertical, light-seeking growth, presumably within poorly lit, more turbid or deeper setting.

These and closely similar stromatolites, also from the Itaiacoca Group about 130 km to the southwest, are attributed to *Conophyton garganicum*. They differ significantly in their axial zones and lamination from other forms of *Conophyton* in the Paranoá Group known from the São Francisco Craton 500 km or more to the north. Apparently, *Conophyton* in these two regions formed in different depositional settings and/or at different times. — (*December 10, 1999*) .

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THEMES ON EARTH, PHYSICAL AND MATHEMATICAL SCIENCES

Organizers:

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δ^{13}C FLUCTUATIONS IN PRECAMBRIAN TO CAMBRIAN CARBONATE SEQUENCES IN NE BRAZIL AND NW ARGENTINA

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Carbon isotopes in carbonate sequences of Brazil and Argentina were analyzed in this study. In NE Brazil, rather unfossiliferous, weakly metamorphosed limestones of uncertain Neoproterozoic age are found in Ceará (Frecheirinha Fm) and Sergipe (Jacoca, Olho D'Agua and Acauã Fms) states. In Argentina, Upper Precambrian and Lower Cambrian, weakly metamorphosed sedimentary carbonates from two areas were studied here: (i) provinces of Salta (carbonates of the Lerma Group); (ii) province of San Juan (La Laja Fm., Precordillera; limestones intercalated with low-grade metapelites of the Pie de Palo complex, Precordillera basement).

The Frecheirinha Fm. shows negative δ^{13}C values in its lower portion ($-2‰_{PDB}$) and positive values up section ($+1$ to $+3‰_{PDB}$), a behavior observed in cap carbonates, deposited after glacial events $\sim$ 0.95Ga. The Jacoca and Acauã limestone Fms. show similar δ^{13}C (average $\sim -5‰_{PDB}$), compatible with deposition at $\sim$ 0.76Ga. In this region, the Olho D'Agua Fm. displays negative δ^{13}C values ($-3‰_{PDB}$) at its lower portion, shiftting up section to $\sim +10‰_{PDB}$, compatible with deposition $\sim$ 0.69Ga.

δ^{13}C in Las Tienditas carbonates (Lerma Group) shows the highest values ($+3.4‰_{PDB}$) at the basis of the section, decreasing gradually upsection. Clayey levels ocurr in the uppermost 15 m of the Formation. A negative excursion ($-1.6‰_{PDB}$) is observed in this interval and likely record the Precambrian-Cambrian transition (PCT). In the basis of La Laja Fm., δ^{13}C shows a negative ($-2‰_{PDB}$) excursion that is followed by a positive one ($+0.5‰$). An anomaly ($-2‰_{PDB}$) is observed $\sim$ 240m from the basis of the Formation, and from 320m up, there is little variation (-0.5 to $-0.1‰_{PDB}$). The PCT seems to have been registered at the basis of this Formation.

Carbonates from three localities in the Pie de Palo complex display distinct δ^{13}C profiles: $\sim 0.0‰_{PDB}$ in the Pozo carbonates, from -1.0 to $0.0‰_{PDB}$ in Ciampo Venato, and from -1.4 to $+1.3‰_{PDB}$ in San Ceferino. This narrow C-isotope variation is compatible with a Mesoproterozoic age deposition. — (*May 19, 2000*) .

CARBON ISOTOPES AND THE K-T BOUNDARY IN ARGENTINA AND CHILE

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In South America, only in few localities the K-T boundary is recorded in limestones: (a) Pernambuco-Paraiba coastal basin, NE Brazil, (b) Yacoraite and Neuquen basins, Argentina and (c) Darwin's Navidad and Magellan basins, Chile.

At the Yacoraite basin, Jujuy and Salta provinces, NW Argentina, the K-T boundary has been recorded in a 2m-thick reddish marl layer at the bottom of the Tunal Fm. which overlies limestones of the Yacoraite Fm. (e.g. at Cabra Corral, $\sim$ 70 km NW from Salta town) and also at Maimara, north of Jujuy, where Tertiary sandstones with calcitic cement overlie $\sim$ 50 m-thick Maastrichtian limestones.

At Punta Topocalma, Darwin's Navidad basin, the K-T boundary is represented by a thin conglomerate layer, on top of Maastrichtian calcitic sandstones and coquina beds, which is covered by unfossiliferous sandstones with calcitic cement. At Punta Algarrobo, very fossiliferous Maastrichtian gray marls are separated by a thin conglomerate layer from a Tertiary marls with trace fossils.

In the Magellan basin, Upper Maastrichtian glauconitic arenite, sandstones with calcareous cement and limestone concretions of the Punta Rocallosa Fm. are covered by sandstones, claystones, limestones with limestones concretions of the Upper Maastrichtian-Lower Paleocene Chorillo Chico Fm. The K-T boundary is at the lower portion of the Chorillo Chico Fm.

The Yacoraite Fm. (Maimara and Cabra Corral localities) exhibits δ^{13}C values between $+1$ and $+2‰_{PDB}$, and a remarkable drop in the K-T boundary to values of $-4‰_{PDB}$. In the Tunal Fm., values range from -3 to $-1‰_{PDB}$. At Punta Rocallosa, δ^{13}C varies from -4 to $-33‰_{PDB}$, and the lowest value within the Chorillo Chico Fm. marks the K-T transition. At Topocalma, δ^{13}C shows negative values whose minimum value ($-30‰_{PDB}$) probably corresponds to the K-T boundary. Oxygen isotopes suggest that temperature drop drastically at the K-T boundary in NE Brazil, while in Chile and Argentina, temperature raised abruptly. — (*May 19, 2000*) .

U-PB DATA FOR GRANULITES OF THE ANÁPOLIS-ITAUÇU COMPLEX: EVIDENCE FOR TWO HIGH-GRADE EVENTS IN THE BRASÍLIA BELT

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The Tocantins Province represents a large Neoproterozoic orogen in central Brazil. The Brasília Belt consitutes the eastern half of the province, along the western margin of the São Francisco Craton. High-grade rocks occur in three mafic-ultramafic complexes (Barro Alto, Niquelândia and Cana Brava), as well as in the Anápolis-Itauçu Complex (AIC), in the central-southern part of the belt.

The AIC includes: (i) orthogranulites represented by mafic-ultramafic complexes, charnockites, tonalitic gneisses, and (ii) supracrustal granulites including sillimanite-garnet gneisses, marbles and quartzites. Narrow volcano-sedimentary belts made of amphibolites and micaschists are also recognized. Intruded into the high grade rocks are a large number of peraluminous granites, some of which also display high grade mineral assemblages. The rocks of the AIC have been traditionally been interpreted as part of the ancient (Archaean/Paleoproterozoic) sialic basement of the Brasília Belt sediments.

The studies have demonstrated that the high-grade metamorphic event which affected rocks of the mafic-ultramafic complexes occurred at ca. 760-780 Ma (U-Pb zircon and Sm-Nd garnet ages). Preliminary Sm-Nd data for the AIC granulites, on the other hand, indicate that the metamorphic mineral assemblages were formed at ca. 620 Ma.

New U-Pb zircon ages for the AIC rocks indicate that: (i) the granites crystallized at ca. 630-640 Ma (U-Pb ages of igneous zircon crystals), and (ii) the metamorphism happened roughly at the same time (ca. 630 Ma).

The data available suggest, therefore, that two events of high-grade metamorphism took place in the Brasília Belt during the Neoproterozoic. The earlier event (ca. 760-780 Ma) is well documented in granulitic rocks of the northern segment of the belt (Barro Alto, Niquelândia and Cana Brava complexes), whereas the younger (ca. 630 Ma) is registered in granulites of the AIC, in the southern part of the Brasília Belt. The 760-780 Ma event is prelim-

inarily interpreted as the result of the collision between the Goiás Magmatic Arc and the western margin of the São Francisco continent, and the ca. 630 Ma as indicative of final ocean closure. — (*May 19, 2000*) .

HYDROTHERMAL FEATURES IN THE CATALÃO I CARBONATITE COMPLEX, GOIÁS

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Presented by ALCIDES N. SIAL

The Catalão I Carbonatite Complex is situated in southwestern Goiás, about 10Km from the Catalão town. Its emplacement occurred in the Cretaceous and it is essentially composed of phlogopitites and carbonatites. In the central part of the complex, in the open pit of the Ultrafértil Mine, there is one remarkable system of hydrothermal activity, related to the final magmatic stages. Compared to other carbonatite complexes the system is unique due to its intensity and singular features. The hydrothermal rocks are mainly composed of apatite, ilmenite, monazite, and barite, which vary from 20 up to 30m thick. Their most important structural features include horizontal layering and banding, dykes, veins, veinlets, and breccia pipes. The system was clearly multistage as demonstrated by crosscutting veins, dykes, and pipes. Whenever the fluid intruded carbonatites a reaction between fluid and rock resulted in important assimilation and erosion of the walls but, if in contact with phlogopitites, no visible reaction is detected. In the first case, the product is a horizontal layered rock composed of apatite and ilmenite that can reach about 0.3 up to 2.0m in thickness, which is differentiated upwards to layers mostly composed of ilmenite and monazite. In the second case, the hydrothermal rocks are mainly composed of apatite and barite. Dyke feeders and pipe roots are often observed. The breccia pipes present a cone shape with a cross section that is roughly circular and that varies from 1cm up to 1.0m in diameter. The fragments in the breccias are derived directly from the wall rocks and show small displacements. Fragments are angular and present a large range of grain size. Few pipes are composed of three main portions: a) a base that is filled with more equigranular fragments (millimeter to centimeter sizes) and that is almost massive; b) a medium portion that is finer (sizes up to few millimeters) and very well layered. In this portion the pipe widens up; c) the uppermost portion that is filled with the breccia that is typical of these pipes. Horizontal fractures, probably due to caldera collapse, were the main conduits to the fluids resulting in structures largely determined by conduit flow mechanisms. Increasing pressure was released through vertical fracture intersections originating the breccia pipes. — (*May 19, 2000*) .

SALINIZATION RISK ASSESSMENT IN IRRIGATED ALLUVIUM AREAS OF SEMI-ARID REGIONS

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Presented by ALCIDES N. SIAL

Soil and groundwater salinization occurs mainly in arid and semi-arid regions. It may arise due to climate conditions, but is more prevalent where irrigation practices alter the natural salt balance. Irrigation can promote salinization by raising the water table of the underlying aquifer, carrying salts upwards either from saline groundwater or from soil profile. Salts, unlike water, remain in the soil as soil evaporation and plant transpiration take place. Salts accumulated in the soil can also be moved downwards through irrigation or groundwater fluctuations, and eventually penetrate the aquifer, thereby reinforcing the salinity problem.

Control of salinisation is a key factor for sustainable irrigated agriculture, in which maximum crop yield is desirable at the same time as natural resources are preserved. Irrigation management proposals, aiming salinity control, depend upon assessment of salinity levels. Mathematical models provide the means for predicting the behavior of physical systems, and thus may be applied to design and management studies considering different scenarios of water use and quality.

Heterogeneity of the soil hydraulic properties and their associated measurement errors constitute the major sources of uncertainties in modeling the movement of water and solutes (salts) in field soils. Consideration of these uncertainties in a stochastic modeling framework leads to the possibility of quantifying the uncertainty in the model's output variables, which are in turn basic information for salinity risk assessment and proposal of management strategies.

Existing methodologies and mathematical models

have been combined and adapted to develop an useful tool for salinity risk assessment in shallow groundwater systems, accounting for spatial variability and measurement errors associated with the soil hydraulic properties.

A case study is presented, based on a small- scale irrigation project in the Northeast of Brazil. The importance of this system is related to its general characteristics which make it a paradigm for a large number of similar ones in the region. Groundwater quality and quantity in the system have been monitored for the last four years. Evidences of degradation by salinization can already be noticed. Stochastic analysis is performed to show examples of the impact of different scenarios of irrigation water quantity and quality on plant yield. — (*May 19, 2000*) .

ISOTOPE STRATIGRAPHY IN PETROLEUM EXPLORATION

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Presented by ALCIDES N. SIAL

Chemical, physical and biological modification of ocean water in geological time generally produces variations in the concentration, chemistry and isotopic composition of organic matter and carbonate precipitated from this water. Some of these modifications are related to global events and can be considered excellent chronostratigraphic markers.

From such gobal events, the anoxic and glacial events are particularly important in petroleum exploration. The former represents the best environmental conditions for concentration and preservation of organic matter and the later is responsible for glaucioeustatic sea-level fluctuations, which may be regarded as a driving mechanism for turbidite formation. Turbidites comprise the most important oil reservoir of Brazilian offshore sedimentary basins.

The occurrence of anoxic events in geological time can be normally related to positive anomalies in carbon stable isotopic data, whereas the the glacila events are easily defined by relatively abrupt increases of δ^{18}O values.

In this study, we report th Stable isotopic signatures of the Cenomanian-Turionian anoxic events in the Sergipe-Alagoas Basin and the Tertiary glaucioeustatic fluctuations in Campos Basin based on oxygen stable isotope data. — (*May 19, 2000*) .

RECONSTRUCTION OF PALEOENVIRONMENTS USING CARBON STABLE ISOTOPES OF SPECIFIC COMPOUNDS

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Presented by ALCIDES N. SIAL

Representative samples from two contrasting paleoenvironments, *e.g.*, lacustrine and marine-evaporitic, were analyzed using the *Isotope Ratio Monitoring-Gas Chromatography-Mass Spectrometry* (IRM-GC-MS) technique to assess the carbon isotopic compositions of saturated hydrocarbons. Those compounds were previously separated from the bulk organic extracts using molecular sieving.

Systematic variations in the abundance of ^{13}C in saturated hydrocarbons were used to assess the conditions of the lacustrine (Neocomian) and lagoonal to restricted marine (Aptian) paleoenvironments of the Pendência and Alagamar Formations, respectively, from the Potiguar Basin, Northeast Brazil.

In the lacustrine section, the isotopic compositions of compounds formed in the photic zone, *e.g.*, pristane, β-carotane, and some *n*-alkanes vary only slightly with depth, suggesting consistent conditions at the water surface. However, there are dramatic changes in the isotopic compositions of hopanoids produced by bacteria that inhabited the lower part of the Pendência paleolake. The δ^{13}C values of those hopanoids indicate an effective stratification of the water column and an active recycling of methane.

In the marine-restricted section, δ^{13}C values of *n*-alkanes vary systematically with depth but not with carbon number, indicating dominance of a single source for all *n*-alkanes, independent of carbon number, and secular variations in the isotopic composition of that source. Those variations can be correlated with global changes in the isotopic compositions of marine dissolved inorganic carbon associated with the oceanic anoxic event that occurred in the Upper Aptian (OAE-1). The hopanoids are the most depleted in ^{13}C among saturated hydrocarbons and reflect contributions from chemoautotrophs, and in extreme cases from methanotrophs. The covariations between de δ^{13}C of pristane and phytane, and these acyclic isoprenoids and β-carotane suggest a common origin from

phytoplankton. Gammacerane has $\delta^{13}C$ values compatible with a derivation from bacterivorous ciliates feeding on algae and cyanobacteria growing under variable paleoenvironmental conditions.

The objectives of the present study are to identify biogeochemical processes involv ed in the production, reworking, and preservation of the organic matter, and consequently to improve the understanding of the lacustrine and marine-evaporitic sections of the Potiguar Basin, Northeast Brazil. — (*May 19, 2000*) .

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CHEMICAL, STRUCTURAL AND OPTICAL CHARACTERISATION OF GEMOLOGICAL TOURMALINES FROM PEGMATITES OF THE PEGMATITIC PROVINCE OF BORBOREMA - BATALHA, CAPOEIRAS, QUINTOS AND BULANDEIRA - IN THE DISTRICTS OF RIO GRANDE DO NORTE AND PARAÍBA, NE OF BRAZIL

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Presented by ALCIDES N. SIAL

The aims of this work are to characterize the chemical, structural and optical features of gemological tourmalines from four pegmatites in the Pegmatitic Province of Borborema, districts of Rio Grande do Norte and Paraíba, Northeast Brazil. Special emphasis has been devoted to colour and its generation.

The studies were based on several techniques, namely EPMA, ICP-MS, ICP-AES, X-Ray diffraction of single crystal, Raman Spectroscopy, DTA-TG, Visible and IR absortion Spectroscopy, ESCA and refractive indexes determination through an Able refractometer.

The studied elbaites showed different colours which were classified as green-blue, red and colourless. A close relationship between minor and trace chemical composition – Fe, Cu, Zn, Mn, Ca, Ti and Mg – and colour has been determined. Red colour has been shown to be related to Mn^{3+} and possibly to electron trap colour centres. The colour of green and blue elbaites is related to Fe^{2+} d-d transitions and/or charge transfer $Fe^{2+} - Fe^{3+}$ and $Zn^{2+} - Fe^{3+}$ interactions. The purple colour has been related to Cu^{2+} d-d transitions.

The thermal treatment revealed that the colour of elbaites changes at 600°C. The red ones become colourless due to the loss of the Mn^{3+} absorption. The purple ones become turquoise-green due to the loss of Mn^{3+} absorption while those of Cu^{2+} remain. Those green and blue elbaites become yellowish by the loss of Mn^{3+} absorption and the generation of Fe^{3+} absorption and centres $Fe^{3+} - Fe^{3+}$. A common feature for all the samples is an endothermic transformation which corresponds to the loss of weight (3.6%) when the dehydroxilation occurs.

All the samples analyzed do not present important differences in the XRD patterns and Raman spectra. Regarding the Raman spectra, the most pronounced differences were found in the low-frequency region where the greatest influence of the minor/trace elements occur. — (*May 19, 2000*) .

SIGNIFICANCE AND GENETIC INTERPRETATION OF THE SEQUENTIAL ORGANIZATION OF THE APTIAN-ALBIAN LACUSTRINE SYSTEM OF THE ARARIPE BASIN

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Presented by ALCIDES N. SIAL

The Aptian-Albian lake system studied here is inserted in the post-rift sedimentary infill of the Araripe basin. Based on surface and subsurface data it was possible to demonstrate that this lacustrine dispositive interacted with one or various fluvio-deltaic environments which contributed with terrigenous materials into the lake. The lacustrine sequence was defined as a interdigitation set within the carbonated and terrigenous bodies. Six main episodes of lacustrine carbonated sedimentation (C1 to C6) were registered in this lacustrine sequence. The successions were grouped in transgressive-regressive sequences of different orders and hierarchies. These successions was developed by minor transgressive-regressive successive pulses (minor frequency sequences). The whole sequence behaved like an expansive lake. The main transgressive pulses considered significant to the sequential subdivision of the lacustrine record, overflowed the depositional area, occupping even major regions in the basin, so that the last lacustrine episodes (immediately before the final evolution of the lacustrine system) reached more extension areas. Each intermmediate order transgressive-regressive

sequence occurred with small transgressive-regressive pulses, which produced periods of relative estabilization. The whole association of trangressive-regressive pulses had a duration of aproximately 1 to 3 millions years and was divided into six episodes (C1 to C6) characterized by the main transgression, which had a duration varying from 200,000 to 500,000 years. In conclusion, it was possible to define the hierarchy of the lacustrine sequence which order was the result of a junction of climatic and tectonic factors that controlled the evolution of the Aptian-Albian lacustrine system of the Araripe basin. Further studies, for example, a high resolution analysis of the terrigenous and carbonated lacustrine sequences will permit to advance in a proposal of genetic-sequential analysis according to the characteristics of the lacustrine dispositive that generated it. — (*May 19, 2000*) .

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HIGH QUALITY SYNTHETIC QUARTZ CRYSTAL GROWTH FOR THE INFORMATION TECHNOLOGY

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Presented by ALCIDES N. SIAL

Since the first application of piezoelectric property of quartz crystal in the electrical circuit for frequency control in 1921 (Heising, 1985), its application has been increased in several areas such as in the telecommunication system networks and electronic microprocessors mainly due to its high stability and effective cost/performance. However, due to the limited volume of natural quartz of quality and its high cost for such applications, a technology known as hydrothermal process was established in 70's for the mass production of synthetic quartz crystals. This technology involve quartz seeds and lascas of natural quartz as nutrient to grow the synthetic quartz crystals. Nowadays, the annual production of the synthetic quartz in the world is about 2.000 ton.

The advent of cellular and satellite networks of high frequency, smaller, cost effective resonators demand improved uniformity in quartz materials (Balascio and Lind, 1997). Even though, the final quality depends mainly on the growth conditions, it is well known the seed quality play an important role. Therefore, the seed technology is crucial. One of methods is use of high quality natural quartz seeds to grow synthetic quartz crystals of high crystallline perfection. At present, there are some supplies of suitable crystals from Madagascar, but Brazil remains at present the most important source. Even though there are possibilities that large areas are still geologically unexplored, large well formed crystals are becoming rare, very expensive and involving a very specialized techniques for the inspection of big blocks.

Since the establishment of synthetic quartz technology, several efforts have been done to improve the crystalline perfection and purity of synthetic quartz crystals. In this presentation, results of recent research works to obtain high quality synthetic quartz crystals in Brazil and in abroad are summarized (Shinohara et al., 2000). Furthermore, the present Brazilian conditions in terms of production of natural quartz crystals for synthetic quartz industries are presented and discussed. — (*May 19, 2000*) .

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GEOCHEMICAL STUDIES OF THE AMAZONIAN BASIN USING TRANSITION ELEMENTS AND REE

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Presented by ALCIDES N. SIAL

The Amazon River with an extension of 6.1 $10^6 km^2$ and more than 1000 tributaries has an average discharge volume of 209000 m3/s, suppling up to 15% of all the river water discharged to the ocean (Salati and Vose,1984). The Amazon River results of the mixing of two different types of waters: the blacks waters and the whites ones, chemically very well differentiated. The information given by the chemical studies of transition and REE elements, in addition with that given by the environmental context allows us to discriminate the origin and the quality of the waters and sediments encountered in the Amazonian rivers and to highlight the behaviour of a large number of trace elements. This work was part of the HiBAm program (Hidrologia e Geoquímica da Bacia Amazônica) which is supported by the CNPq/UnB/ANEEL/IRD partnership research program. The water samples were filtrated on 0.22μm Millipore membrane filters, in the laboratory of

the research vessel, trace elements V, Cr, Mn, Co, Cu, Zn, As, Rb, Sr, Mo, Cd, Sb, Cs, Ba, U and REE analysis were performed by Inductively Coupled Plasma-Mass Spectrometry(ICP/MS) using a VG-Elemental PQ2 instrument at the Laboratoire de Géochimie (Montepellier University, France). REE analysis were performed by ICP-Atomic Emission Spectrometry using a Spectroflame FVM03 instrument in Geochemistry laboratory (Brasília University, Brazil). Dissolved REE results vary by more than a factor 10. The highest concentration is found in the Negro river (200 ppt for La, 500 ppt for Ce, 2 ppt for Lu) and the lowest in the Tapajós river (La: 21 ppt, Ce: 27ppt, Lu: < 0.1ppt). The REE behaviour in the Amazon rivers differs among the studied fractions. In the dissolved fraction, the REE concentration depends upon the source as well as the physical chemistry conditions (pH) and the amount of organic carbon. (DOC). In the particulate fraction (suspension material and bed load), REE behaves in a differentiated way. The correlation between pH and V, Cu, As, Sr, Cr, Mn, Co, Ni, Ba and U suggest that these elements have a common carbonate and/or evaporite source. However, Cr and Co closely correlate with Dissolved Organic Carbon. The correlation between Zn and Pb reflects a control by source rocks, probably sulfide mineralization where Zn and Pb are commonly associated. The geochemical studies of the Amazonian Basin have provided important information about the trace elements and REE behaviour in a such type of riverine environment. — (*May 19, 2000*) .

POLYMER BASED GAS SENSORS*

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The electrical properties of conducting polymers samples are extremely sensitive to the environment. This property can be cleverly exploited to the development of sensors responding to the presence of even small amounts of gases and vapors. Electronic noses - i.e. devices which are able not only to indicate the presence of introduced aroma but also of identifying them in an unequivocal manner - based on the different level of response of each individual polymeric sample disposed as members of a small sensor array have been recently developed.

We discuss recent work done by our Group in Recife, where a cooperative team of physicists, chemists and computer scientists have devised new manners of preparing very thin films of conducting polymers and implemented ways of automatically collecting the fractional change in the electrical resistance of the samples and processing the input signals for the recognition of specific patterns which could be associated to the presence of simple and complex aromas.

In their successive versions, the instruments developed by our Group have been used not only to identify the presence of vapors of common organic solvents but also to analyze wines of different kinds. The degree of accuracy attained was above 90% even for the task of identifying vintages of a same type of red wine. At present, efforts are directed to the development of electronic noses which could operate as real time instruments, providing in situ analysis for different applications. The importance of such devices, for instance in the quality control in the food and beverage industry, and in the monitoring of environmental quality in the gas and oil plants, can hardly be overstated. — (*May 19, 2000*) .

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DISCOVERING INFORMATION THROUGH VIRTUAL REALITY

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Presented by ALCIDES N. SIAL

The main definitions and technologies related to virtual reality in the turn of the millennium will be presented in this talk. Those types of virtual reality capable of being built and employed in home PCs will be stressed, showing successful applications of this technology to every-day problems. Some of these applications are related to the modelling, exhibition and visiting of historical buildings, to the learning of mathematical concepts, to the description of and interaction with urban scenarios, to the proposal of three-dimensional navigation tools for synthetic environments and to the realistic and interactive recreation of historical events. Both the creation and the use of virtual reality applications will be commented, aiming at educational applications. The impact of virtual reality technologies in education will be shown. — (*May 19, 2000*) .

COUNTING RATIONAL PLANE CURVES

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This is a repport on work by J. Kock. A rational plane curve of degree d is the image of a nonconstant map $t \to (x(t), y(t))$, where $x(t)$, $y(t)$ are rational functions (quotient of polynomials) with maximal degree d. Let $M(0, d)$ be the space parametrizing the family of rational plane curves of degree d. This is a variety of dimension $3d - 1$. The *characteristic* number $n(d; a, b, c)$ of such plane curves containing a general points, tangent to b general lines and tangent to c other general lines at marked points is finite provided $a + b + 2c = 3d - 1$. Until quite recently only the first few were known. Using techniques of stable maps and ideas first developed by M. Kontsevich [Ko], Joachim Kock [JK] obtained in his doctoral thesis WVDD-like PDE's for the tangent potential, *e.g.*,

$$G(u1, u2, v1, v2) = \Sigma u^{\wedge}\alpha/\alpha!v^{\wedge}\beta/\beta!d^{\wedge}(\alpha 1)n(d; \alpha 2, \beta 1, \beta 2),$$

where the sum runs over all $d > 0$ and nonnegative vectors $\alpha = (\alpha 1, \alpha 2)$, $\beta = (\beta 1, \beta 2)$. Those PDE's allow for effective recursive computation of the characteristic numbers. — (*May 19, 2000*) .