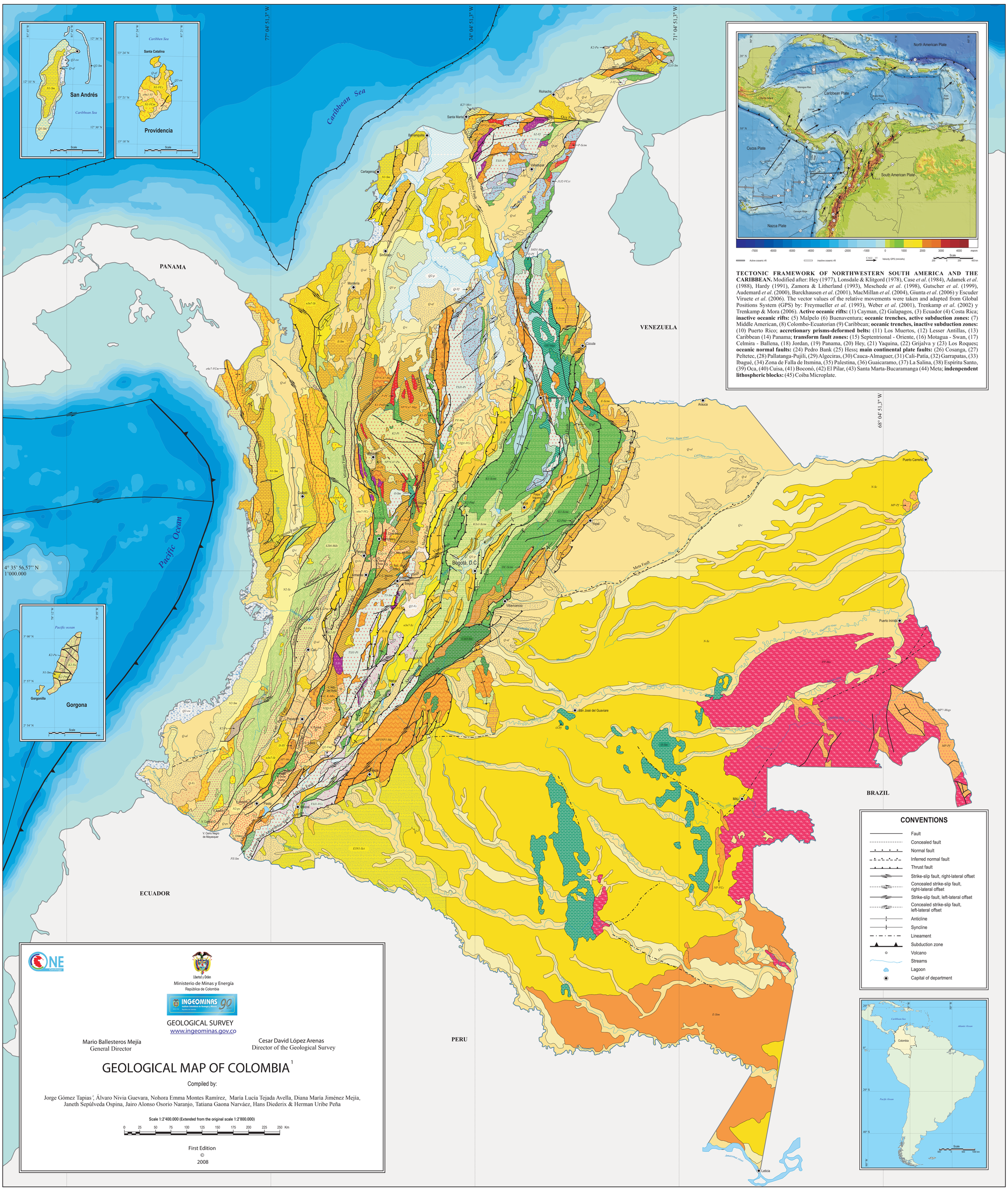
# Geologic Map

RONDA Colombia 2012




**TECTONIC FRAMEWORK OF NORTHWESTERN SOUTH AMERICA AND THE CARIBBEAN.** Modified after: Hey (1977), Lonsdale & Klitgord (1978), Case *et al*. (1984), Adamek *et al*. (1988), Hardy (1991), Zamora & Litherland (1993), Meschede *et al*. (1998), Gutscher *et al*. (1999), Audemard *et al*. (2000), Barckhausen *et al*. (2001), MacMillan *et al*. (2004), Giunta *et al*. (2006) y Escuder Viruete *et al*. (2006). The vector values of the relative movements were taken and adapted from Global Positions System (GPS) by: Freymueller *et al*. (1993), Weber *et al*. (2001), Trenkamp *et al*. (2002) y Trenkamp & Mora (2006). **Active oceanic rifts:** (1) Cayman, (2) Galapagos, (3) Ecuador (4) Costa Rica; **inactive oceanic rifts:** (5) Malpelo (6) Buenaventura; **oceanic trenches, active subduction zones:** (7) Middle American, (8) Colombo-Ecuatorian (9) Caribbean; **oceanic trenches, inactive subduction zones:** (10) Puerto Rico; **accretionary prisms-deformed belts:** (11) Los Muertos, (12) Lesser Antillas, (13) Caribbean (14) Panama; **transform fault zones:** (15) Septentrional - Oriente, (16) Motagua - Swan, (17) Celmira - Ballena, (18) Jordan, (19) Panama, (20) Hey, (21) Yaquina, (22) Grijalva y (23) Los Roques; **oceanic normal faults:** (24) Pedro Bank (25) Hess; **main continental plate faults:** (26) Cosanga, (27) Pelltetec, (28) Pallatanga-Pujili, (29) Algeciras, (30) Cauca-Almaguer, (31) Cali-Patía, (32) Garrapatas, (33) Ibagué, (34) Zona de Falla de Itsmina, (35) Palestina, (36) Guaicaramo, (37) La Salina, (38) Espiritu Santo, (39) Oca, (40) Cuisa, (41) Boconó, (42) El Pilar, (43) Santa Marta-Bucaramanga (44) Meta; **indenpendent lithospheric blocks:** (45) Coiba Microplate.

## CONVENTIONS

- Fault
- Concealed fault
- Normal fault
- Inferred normal fault
- Thrust fault
- Strike-slip fault, right-lateral offset
- Concealed strike-slip fault, right-lateral offset
- Strike-slip fault, left-lateral offset
- Concealed strike-slip fault, left-lateral offset
- Anticline
- Syncline
- Lineament
- Subduction zone
- Volcano
- Streams
- Lagoon
- Capital of department

Libertad y Orden
Ministerio de Minas y Energía
República de Colombia

INGEOMINAS 90

GEOLOGICAL SURVEY
www.ingeominas.gov.co

Mario Ballesteros Mejía
General Director

Cesar David López Arenas
Director of the Geological Survey

# GEOLOGICAL MAP OF COLOMBIA [1]

Compiled by:


Jorge Gómez Tapias [2], Álvaro Nivia Guevara, Nohora Emma Montes Ramírez, María Lucía Tejada Avella, Diana María Jiménez Mejía, Janeth Sepúlveda Ospina, Jairo Alonso Osorio Naranjo, Tatiana Gaona Narváez, Hans Diederix & Herman Uribe Peña


Scale 1:2'400.000 (Extended from the original scale 1:2'800.000)

0 25 50 75 100 125 150 175 200 225 250 Km

First Edition

2008

Courtesy:
Colombian Geological Survey (Before INGEOMINAS)
Geologic Map of Colombia, First Edition 2008
Further information: mapageo@ingeominas.gov.co

# Geologic Map

RONDA Colombia 2012

## LEGEND

CHRONOSTRATIGRAPHIC UNITS CODES

*MP3NP1-Mg*

Mesoproterozoic-Neoproterozoic — Granulite facies metamorphic rock

AGE ' + LITHOLOGY

**DEPOSITS** — Type of deposit: Alluvial (*al*); Terrace (*t*); Alluvial fan (*af*); Paludal (*p*); Glacial (*gl*); pyroclastic (*py*); Dune (*d*); Swamps (*sw*); Volcaniclastic (*vc*)

**ROCKS**

**SEDIMENTARY (S)** — Environment: Continental (*c*); Marine (*m*); Transitional [1] (*t*); Continental - Transitional - Marine (*ctm*); Continental - Transitional [1] (*ct*); Transitional [1] - Marine (*tm*)

**VOLCANICLASTIC (VC)** — Environment: Continental (*c*); Marine (*m*); Continental-Transitional [1] (*ct*)

**IGNEOUS (I)**

- VOLCANIC (V) — Composition: Ultramafic (*u*); Mafic (*mf*); Intermediate (*i*); Felsic (*f*)
- (H)[3] — Composition: Intermediate (*i*); Felsic (*f*)
- PLUTONIC (P) — Composition: Ultramafic (*u*); Mafic (*mf*); Intermediate (*i*); Felsic (*f*)

**METAMORPHIC (M)**

- REGIONAL METAMORPHISM — Metamorphic facies: Subgreenschist facies (*sgs*); Greenschist - amphibolite facies (*gs*); Amphibolite (*a*) - granulite (*g*) facies; Blueschist facies (*bs*); Marble [1] (*mb*)
- DYNAMIC METAMORPHISM (*d*) — Protolite: Sedimentary (*s*)

| Eon | Era | Period | Epoch | Age | Ma |
|---|---|---|---|---|---|
| FANEROZOIC *PH* | CENOZOIC *CZ* | QUATERNARY *Q* | | HOLOCENE *Q2* | |
| | | | | PLEISTOCENE *Q1* | 1,75 |
| | | NEOGENE *N* | PLIOCENE *N2* | Gelasian *n9* | |
| | | | | Piacenzian *n8* | |
| | | | | Zanclean *n7* | 5,30 |
| | | | MIOCENE *N1* | Messinian *n6* | |
| | | | | Tortonian *n5* | |
| | | | | Serravalian *n4* | |
| | | | | Langhian *n3* | |
| | | | | Burdigalian *n2* | |
| | | | | Aquitanian *n1* | 23,5 |
| | | PALEOGENE *E* | OLIGOCENE *E3* | Chattian *e9* | |
| | | | | Rupelian *e8* | 33,7 |
| | | | EOCENE *E2* | Priabonian *e7* | |
| | | | | Bartonian *e6* | |
| | | | | Lutetian *e5* | |
| | | | | Ypresian *e4* | 53 |
| | | | PALEOCENE *E1* | Thanetian *e3* | |
| | | | | Selandian *e2* | |
| | | | | Danian *e1* | 65,0 |
| | MESOZOIC *MZ* | CRETACEOUS *K* | UPPER / LATE *K2* | Maastrichtian *k6* | 72,0 |
| | | | | Campanian *k5* | 83 |
| | | | | Santonian *k4* | 87 |
| | | | | Coniacian *k3* | 88 |
| | | | | Turonian *k2* | 92 |
| | | | | Cenomanian *k1* | 96 |
| | | | LOWER / EARLY *K1* | Albian *b6* | 108 |
| | | | | Aptian *b5* | 113 |
| | | | | Barremian *b4* | 117 |
| | | | | Hauterivian *b3* | 123 |
| | | | | Valanginian *b2* | 131 |
| | | | | Berriasian *b1* | 135 |
| | | JURASSIC *J* | UPPER / LATE *J3* | | |
| | | | MIDDLE *J2* | | |
| | | | LOWER / EARLY *J1* | | 203 |
| | | TRIASSIC *T* | UPPER / LATE *T3* | | |
| | | | MIDDLE *T2* | | |
| | | | LOWER / EARLY *T1* | | 250 |
| | PALEOZOIC *PZ* | PERMIAN *P* | | | 295 |
| | | CARBONIFEROUS *C* | | | 355 |
| | | DEVONIAN *D* | | | 410 |
| | | SILURIAN *S* | | | 435 |
| | | ORDOVICIAN *O* | | | 500 |
| | | CAMBRIAN *CA* [4] | | | 540 |
| PROTEROZOIC *PR* | NEOPROTEROZOIC *NP* | | | | 1000 |
| | MESOPROTEROZOIC *MP* | | | | 1600 |
| | PALEOPROTEROZOIC *PP* | | | | 2500 |




**Geological crustal provinces of Colombia**

1. Rio Negro-Juruana Province-RNJP
2. Grenvillian Colombian Province-GCP
3. Arquia Province-AP
4. Caribbean Province-CP
5. La Guajira Province-GP



### BRIEF OUTLINE OF THE COLOMBIAN GEOLOGIC EVOLUTION

In Colombia the Earth crust's basement, presents two contrasting types of rocks separated by the Cauca-Almaguer Fault in the western flank of the Central Cordillera, by the Guachaca Fault at the Sierra Nevada of Santa Marta and by the Simarua Fault at the Guajira Peninsula. To the east it is constituted by metamorphic rocks, mainly sialic, of Precambrian age, whereas to the west of these structures it consists on igneous, mainly volcanic rocks, of simatic composition of Upper Cretaceous age. The separation between these different types of basement is interpreted as a result of the accretion of oceanic lithosphere fragments to the continental active margin of South America during the Campanian-Eocene interval. However, in the eastern metamorphic basement, there have also been recognized three geological provinces denominated Rio Negro-Juruena Province (RNJP), Grenvillian Colombian Province (GCP) and the Arquía Province (AP), believed to be related to the Paleozoic history of collision between the Gondwana and Laurasia continents.

The RNJP makes part of the Guayana Shield, the Gondwanic autochthonous craton, around which nucleation by amalgamation to its west, of Laurasian Continent´s fragments, occurred during the northwestern drift of the latter, relative to Gondwana. The metamorphic rocks of this province (*PP-Ma* and *MP-Pf*) constitute the basement of the Amazonia and the eastern plains and they extend toward the west until a structure of cortical suture that is considered parallel to the east border this of the Eastern Cordillera, but it happens in a more eastern position - the basement of the Serrania of the Macarena is Grenvillian -, buried below the rocks and sedimentary deposits of the border plain. Between this and the San Jerónimo Fault, the crystalline basement (that consists in schists, gneises, amphibolites and granulites) constituted by the GCP that is exposed in the Garzón and Santander Massifs, of the Eastern Cordillera, in form of isolated blocks as well as roof pendants in the Jurassic plutonic rocks of the Central Cordillera, the Serranía de la Macarena, the Sierra Nevada de Santa Marta and the Alta Guajira. The GCP has been affected by diverse orogenic events and/or tectometamorphics during the Ordovician, Silurian?, Devonian, Permian, Triassic and Cretaceous and the last one that still operates, related to the Andean Orogeny. The current knowledge and the absence of paleo-faunistic studies that allow to specify if the fossils paleo-faunas, especially of the Ordovician, belong to North or South America, it prevents to determine the age of amalgamation between the RNJP and the GCP.

A more western belt of metamorphic rocks limited by the Silvia-Pijao and Cauca-Almaguer Faults, constituted by quartz-sericitic and amphibolic schists, and amphibolites, locally granatiferous *(NP?-Ma)* is considered that it constitutes a geologic province of oceanic affinity and even unknown origin denominated AP. The distribution of the sedimentary rocks associated to the GCP and AP Provinces seem to suggest that these could have been amalgamated before the amalgamation of the fragments from the GCP to Gondwana. Indeed, although without precise geochronologic controls, the distribution of the Paleozoic sedimentary rocks that rest on the two provinces seems to suggest that for the Ordovician these constituted a single basement. The devonian and permo-triassic plutons that intrude AP and GCP, postdates the event of amalgamation of both provinces.

The distribution of the Jurassic granitoids, of the jura-cretaceous volcano-sedimentary covering that rest on the crystalline basement and on an ophiolitic belt that it crops out between the GCP and AP province suggest that during most of the Mesozoic the western margin of the continent was active, associated to subduction of dense oceanic crust (relatively old) that promoted the establishment of extensional regimes. The cortical attenuation, for extension in the back arc, gave origin to an intracontinental basin that evolved during the Jurassic and Cretaceous. This basin was slowly invaded by the sea in the early Cretaceous and the sedimentation was controlled by the activity of normal faults at least until the early Albian and for variations in the eustatic level between the middle Albian and the Maastrichtian.

Between the AP and the GCP outcrops the Quebradagrande Complex (*K1-VCm*) constituted by failed blocks of ultramafic rocks, gabbros, basic volcanic rocks and sedimentary rocks. The chemical analysis of the basic volcanic rocks suggest magmatic origin associated to a suprasubduction zone mantle wedge whereas the sedimentary facies, as indicated by the lower Cretaceous fossils collected in the sedimentary intervals indicated that the accumulation environment shifted from continental to marine through transitional and shallow marine. The fossils gathered in these last rocks indicate that the sequence accumulated during the Lower Cretaceous. The lithologic association of the Quebradagrande Complex allows to interpret it as the intracontinental opening of a marginal backarc basin –*sensu stricto*- with formation of oceanic crust that took advantage for its formation the suture areas between the Cajamarca and Arquia complex, those which, constituted the places of more cortical weakness in the moment of formation of this basin.

To the West of the AP, from which it is separated by the Cauca-Almaguer Fault there is the Caribbean Province-CP made of crustal fragments of oceanic affinity. The rocks of this province outcrops on the western foothills of the Central Cordillera, the Western Cordillera and the Serrania del Baudó. There, they consist on strongly faulted and deformed slivers of ultramafic rocks, gabbros and tonalites associated, and also associations of basalts and felsites, there also outcrop picrites and komatiites *(K2-Vi4)* of which those of Gorgona Island are the unique example of Phanerozoic komatiites around the world. Lithologic characteristics of this province like the presence of picrites and komatiites accompanied by the bimodal basaltic-rhyolitic composition of the volcanic rocks as well as their trace element composition suggest that these rocks were formed in an oceanic plateau. In response to its high relief and higher buoyancy relative to the normal oceanic crust this oceanic feature was accreted to the South American active margin during the Eocene by accretion/subduction processes. The arrival and accretion of the oceanic plateau to the continental margin clogged the subduction zone located by then in CP´s western end, in such a way that in order to accommodated the movement of the oceanic plate towards the East, there was a jump of the subduction zone towards the West up to position of the present-day Colombia-Ecuador trench. The formation of this new subduction zone had consequences so much deep as superficial. In the first case, it has given origin to several magmatism pulses whose localization depends on the processes of deformation in the accretionary complex that begin in the Eocene with the generation of the Batolito de Mandé *(E2-Pi)* and the volcanic sequences of Santa Cecilia and La Equis (E2-VCm) that migrate toward the east until occupying the place of the current Andean volcanoes. In surface, on the other hand, they have taken place a series of forea-arc and foreland basins where sedimentary sequences have been deposited whose environmental accumulation has gone varying of marine to essentially continental, with an important contribution of volcanic components generated starting from the erosion of the products of the contemporary magmatic pulses. An orogenic event, generated by the reorganization of the tectonic plates, is responsible for the Andean deformation of these sequences and of a formative phase of the current landscape with depocenter of sedimentary accumulation in basins related to the evolution of the current magmatic arc. Likewise, in La Guajira and the Sierra Nevada de Santa Marta, rocks of oceanic character and Cretaceous age are presented contained inside The La Guajira Province (GP) that given the little knowledge that one has doesn't allow establishing the type of oceanic crust and the time of accretion of the same one.

The CP corresponds to the plateau fragments sutured as an accretionary complex to the continental margin. However, most of the plateau was accommodated between North and South America, displacing toward the east different cortical fragments, such as the Great Antilles that retarded their movement and they facilitated the establishment of a subduction zone under the western margin of the plateau. As a consequence of the subduction at its western edge, a magmatic system that leads to the volcanism of the Central American Isthmus was formed. In addition, at the northeastern boundary of the plateau, in contact with the continental sialic blocks of Central America (Chortis Block), Neogene volcanic activity occurred the at faults and discontinuities associated to extensional stress due to the readjustment between crustal blocks. The building up of the volcanic edifices at shallow marine depths favored conditions for coral reefs growth. The volcanic rocks formed as a result of this activity, outcrop at Providencia Island the center of a ring reef. At San Andres Island the volcanic rocks do not outcrop but made the basement on top of which a platform of reefal limestone was build.

The present-day configuration of the Colombian territory, in particular the Andean zone is then due to the interaction of the Cocos, Nazca, Caribbean, and South American plates and also to the Coiba microplate. The current condition of kinematics and convergence geometrically heterogeneous, especially among the Nazca and South American Plate and their evolution are the responsible for the intensity of the active tectonic processes as they are the subduction, formation of cordilleras, basins and volcanic chains, reactivation and neoformation of cortical structures and an intense seismic activity. This complex convergence interaction is assumed to the interior of the continent in structural relationships in the domain of fields of efforts partitioned from the same area of it couples of the plates. Essentially regional efforts of type transpressive and transtensive are presented, that which favors the expulsion of cortical blocks in address NEE controlled by traverse transcurrent faults to the cordilleras, also taking place, on the previous structures, reactivation relationships that condition the whole deformative process current in the continent.

### REFERENCES


Adamek, S., Frohlich, C. & Pennington, W. 1988. Seismicity of the Caribbean-Nazca Boundary: Constraints on Microplate Tectonics of the Panama Region. Journal of Geophysical Research, 93(B3): 2053-2075.

Audemard, F. A., Machette, M.N., Cox, J.W., Dart, R.L. & Haller, K.M. 2000. Map and database of Quaternary faults in Venezuela and its offshore regions. Escala 1:2'000.000. United States Geological Survey. Denver, CO, USA.

Barckhausen, U., Ranero, C.R., von Huene, R., Cande, S.C. & Roeser, H.A. 2001. Revised tectonic boundaries in the Cocos Plate of Costa Rica; implications for the segmentation of the convergent margin and for plate tectomic models. Journal of Geophysical Research, 106(B9): 19207-19220.

Case, J.E., Holcombe, T.L. & Martin, R.G. 1984. Map of geologic provinces in the Caribbean region. Escala 1:5'000.000. Geological Society of America Memoir 162: 1-30.

Escuder Viruete, J., Díaz de Neira, A., Hernáiz Huerta, P.P., Monthel, J., García Senz, J., Joubert, M., Lopera, E., Ullrich, T., Friedman, R., Mortensen, J. & Pérez - Estaún, A. 2006. Magmatic relationships and ages of Caribbean Island arc tholeiites, boninites and related felsic rocks, Dominican Republic. Lithos, 90(3-4): 161-186.

Freymueller, J.T., Kellogg, J.N. & Vega, V. 1993. Plate motions in the North Andean region. Journal of Geophysical Research, 98(B12): 21853-21864.

Giunta, G., Beccaluva, L. & Siena, F. 2006. Caribbean Plate margin evolution: Constraints and current problems. Geologica Acta, 4(1-2): 265-277.

Gómez, J., Nivia, A., Montes, N.E., Jiménez, D.M., Tejada, M.L., Sepúlveda, M.J., Osorio, J.A., Gaona, T., Diederix, H., Uribe, H. & Mora, M., compiladores. 2007. Mapa Geológico de Colombia. Escala 1:1'100.000. INGEOMINAS, 2 hojas. Bogotá.

Gutscher M., Malavieille, J., Lallemand, S. & Collot, J. 1999. Tectonic segmentation of the North Andean margin: Impact of the Carnegie Ridge collision. Earth and Planetary Science Letters, 168(3-4): 255-270.

Hardy, N.C. 1991. Tectonic evolution of the easternmost Panama Basin: Some new data and insights. Journal of South American Earth Sciences, 4(3): 261-269.

Hey, R. 1977. Tectonic evolution of the CocosNazca spreading center. Geological Society of America Bulletin, 88(10): 1404-1420.

IGAC. 2003. Mapa Oficial de Colombia - Fronteras Marítimas y Terrestres. Escala 1:2'500.000. IGAC. Bogotá.

Lonsdale, P. & Klitgord, K.D. 1978. Structure and tectonic history of the eastern Panama Basin. Geological Society of America Bulletin, 89(7): 981-999.

MacMillan, I., Gansa, P.B. & Alvarado, G. 2004. Middle Miocene to present plate tectonic history of the Southern Central American Volcanic Arc. Tectonophysics, 392(1-4): 325-348.

Meschede, M. & Wolfgang, F. 1998. A plate-tectonic model for the Mesozoic and Early Cenozoic history of the Caribbean Plate. Tectonophysics, 296(3): 269-291.

International Union of Geological Sciences, 2000. International Stratigraphic Chart. International Union of Geological Sciences UNESCO. Paris.

Trenkamp, R., Kellogg, J.N., Freymueller, J.T. & Mora, H.P. 2002. Wide plate deformation, Southern Central America and Northwestern South America, CASA GPS observations. Journal of South American Earth Sciences, 15(2): 157-171.

Trenkamp, R. & Mora, H.P. (en preparación). Actualización de vectores de desplazamiento en la zona del Proyecto CASA. Unpublished results.

Weber, J.C., Dixon, T.H., DeMets, C., Ambeh, W.B., Jansma, P., Mattioli, G., Saleh, J., Sella, G., Bilham, R. & Pérez, O. 2001. GPS estimate of relative motion between the Caribbean and South American plates, and geologic implications for Trinidad and Venezuela. Geology, 29(1): 75-78.

Zamora, A. & Litherland, M. 1993. Mapa Geológico de la República del Ecuador. Escala 1:1'000.000. Corporación de Desarrollo e Investigación Geológico-Minero Metalúrgica (CODIGEM)-British Geological Survey. Keyworth, UK.


### NOTES

1. Generalized geological map from Gómez *et al.* (2007).
2. Any suggestion intending to improve the GMC (2007) please contact geologist Jorge Gómez Tapias at the e-mail: *mapageo@ingeominas.gov.co*.
3. Ages are used following the International Stratigraphic Chart (IUGS, 2000) recommendation.
4. The symbol for the notation of the Cambrian as use by the International Stratigraphic Chart was changed to CA in the map's Legend due to the fact that the former is not included within the characters defined for the Oracle software used to implement the GMC (2007) database.
5. As transition environments are considered the delta plains, costal lagoons, intertidal plains and coastal fans.
6. Hypabyssal rocks.
7. Rocks occurring in several metamorphic facies.
8. The contacts between the deformed sedimentary rocks ***k2k6-Mds*** and the volcanic rocks ***K2-Vmf*** to the west of the Cauca-Almaguer fault are faulted.
9. The Base Map was taken of IGAC (2003).
10. Citation of the GMC (2007) is suggested as:

**Gómez, J., Nivia, A., Montes, N.E., Jiménez, D.M., Tejada, M.L., Sepúlveda, J., Osorio, J.A., Gaona, T., Diederix, H. & Uribe, H, compilers. 2008. Geological Map of Colombia. Scale 1:2'800.000. INGEOMINAS, 1 edition. Bogotá.**