6th International Symposium on Andean Geodynamics (ISAG 2005, Barcelona), Extended Abstracts: 817-820

The Lower Carboniferous of the western edge of Gondwana in Peru and Bolivia: Distribution of sedimentary basins and associated magmatism

Alberto Zapata M. [1], Agapito Sánchez F. [1], Segundo Carrasco V. [1], Agustín Cardona [2], Jorge Galdos H. [1], Fredy Cerrón Z. [1], & Thierry Sempere [3]

[1] Direction of Regional Geology, Instituto Geólogico Minero Metalúrgico (INGEMMET), Lima, Peru
[2] Phd student of the University of São Paulo, Brazil
[3] IRD, LMTG, Observatoire Midi-Pyrénées, 14 avenue Edouard Belin, 31400 Toulouse, France

INTRODUCTION

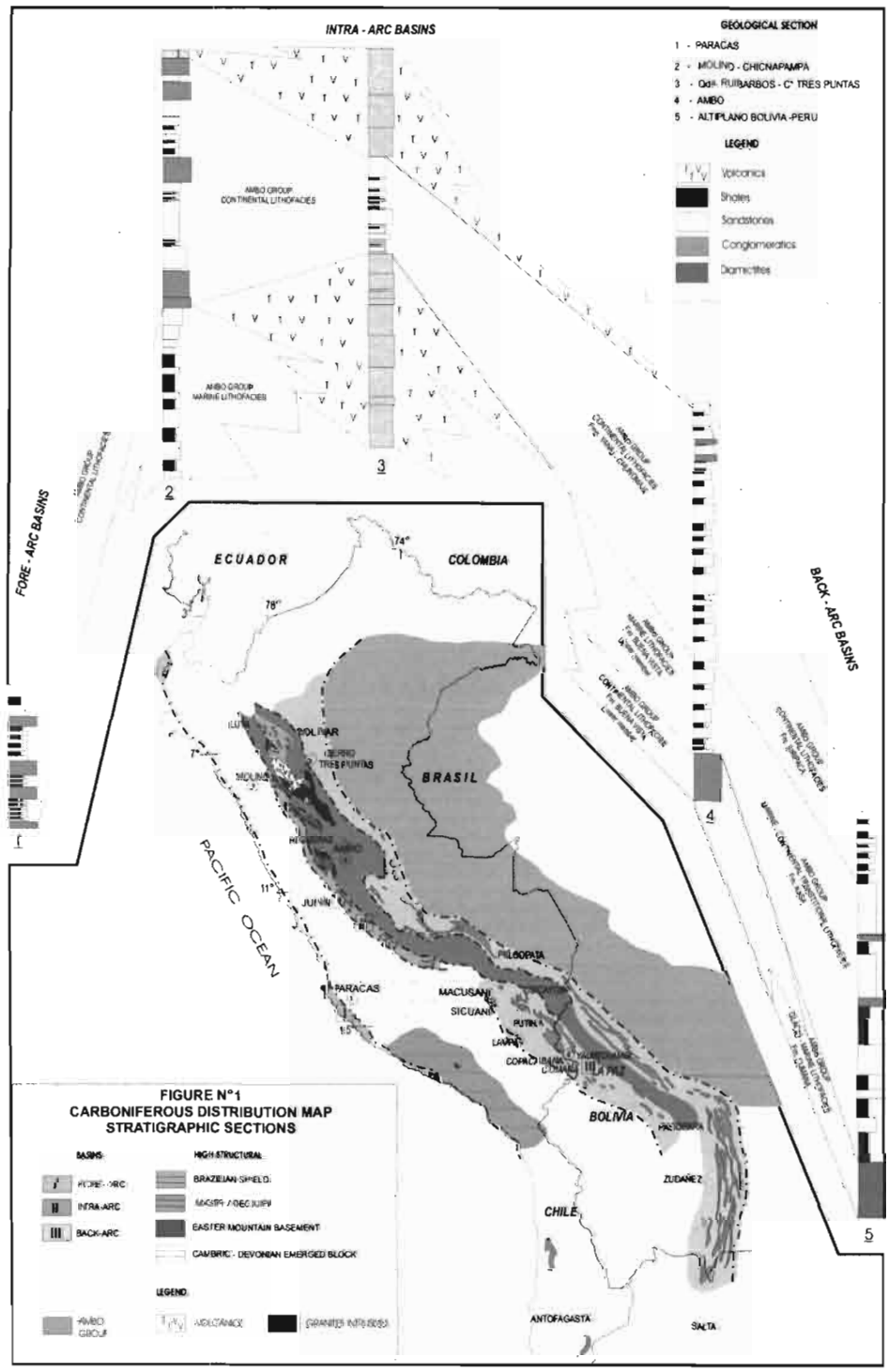
During the Early Carboniferous, the tectono-sedimentary and magmatic configuration of the western edge of Gondwana (Eastern Cordillera of Peru and Cordillera Real of Bolivia, between latitudes 3°S and 24°S; Figure 1) associated a marine and continental sedimentation (Ambo Group), a volcanic arc (Lavasen Formation) and a related plutonism (Pataz-Balsas-Buldibuyo batholith, Higueras pluton, Amparaes and Cadenas granites). The present paper analyses the distribution of the Carboniferous basins and their relationships with Carboniferous magmatism along the western edge of Gondwana.

DISTRIBUTION OF CARBONIFEROUS ROCKS IN PERU AND BOLIVIA

Granitoid emplacements occurred between 374 and 305 Ma (Late Devonian - Late Carboniferous). This magmatism was contemporaneous with marine and continental sedimentation (Ambo Group; Tournaisian-Serpukhovian), which in turn was coeval with the Lavasen volcanism during the Visean-Serpukhovian. The distribution of this calc-alkaline magmatism suggests to separate spatially the Carboniferous basins into fore-arc, intra-arc, and back-arc settings, between the Arequipa Massif in the west and the Brazilian shield in the east.

FORE-ARC BASIN: This basin developed in the area that presently corresponds to the coast of Peru, between the "Arequipa Massif" and a Cambrian-Devonian? block located west of the magmatic arc, during the Famennian-Kasimovian interval. The limits of this western basin are not clear because there exists only a few isolated and reduced outcrops. Thicknesses of about 250 m were measured in La Mina, in the Paracas peninsula (Núñez, 1991), in Puerto Viejo near Chala, and in the Ancocalani and Chinchillane hills north of Tacna (Pino et al., 2004), but they are only minima as the base of the succession is truncated by faults in these outcrops. Along the coast of northern Peru, in the Amotapes hills, Martínez (1970) recognised strata of the Ambo Group as the Chaleco de Paño Formation, which displays lithostratigraphic and biostratigraphic similarities with those along the coast of southern Peru. Deposition apparently developed in a transgressive context. Sedimentary facies are sandstones, conglomerates and mudstones; the recognised paleoenvironments include meandering rivers, coastal swamps, coastal tidal channels, and beaches (Núñez, 1991). Sandstones show a high content of volcanic lithic fragments, pointing to nearby erosion of a volcanic arc (Aleman and León, 2002). The lower deposits have yielded plants (*Tomiodendron* sp., *Cyclostigma pacifica* Steinmann, *Nothorhacopteris* cf. *kellaybelensis*), whereas the brachiopod *Buxtonia peruviana* d'Orbigny and the bryozoan *Fenestrellina* sp. were found in the

upper strata, suggesting deposition spanned the mid-Carboniferous (Alleman, 1988, 1991, 1997; Palacios, 1994; Pino et al., 2004).



INTRA-ARC BASIN: A calc-alkaline arc developed in an area now located within the present-day Eastern Cordillera between latitudes 6°10´S and 13°35´S, probably bounded in the west by an emerged block of Cambrian - Devonian rocks and in the east by the Neoproterozoic basement and its Lower Paleozoic cover. Transtensional tectonics was responsible for block dislocation of the basement, creating four separate basins

(preliminarily referred as the Luya-Cerro Tres Puntas, Molino-Huacrachuco, Ambo, and Junín-Huancavelica basins). Here is a brief description of the magmatism and volcano-sedimentary succession in this area:

Granitoids are distributed along a NNO-SSE discontinous belt of ~1000 km, in the Eastern Cordillera. Individual plutons are emplaced in Lower Paleozoic and Proterozoic rocks. Their composition varies from diorites to quartz-monzogranites. Isotopic ages are comprised between 374 and 305 Ma (Lancelot, 1978; Mégard, 1979; Bonhomme, 1985; Schreiber, 1990; Vidal et al., 1995; Sánchez, 1995; Haeberlin et al., 2002; and A. Cardona, 2005, unpublished). They are subalkaline to calcalkaline (in the latter case they are rich in K and Al, with low percentages of Na and Ca) and present both S- and I-types. Magmatic differentiation involved fractional crystallization and partial assimilation of wall rocks. This magmatism displays synorogenic and postorogenic features.

Volcano-sedimentary successions

***Luya – Cerro Tres Puntas Sector*:** Between latitudes 6°35´S and 8°30´S (Abra Barro Negro and outskirts of the Huascacocha lake), pyroclastic rocks include crystal and crystalolithic tuff of rhyolitic and rhyodacitic compositions. The ~2000 m-thick Lavasen Formation consists of volcanoclastic deposits that interdigitate with continental facies of the upper Ambo Group, along the Ruibarbos quebrada and Cerro Tres Puntas (Zapata et al., 2005).

***Molino – Huacrachuco Sector*:** North of Molino, the continental to marine sandstones and conglomerates of the upper Ambo Group contain a few meters of pyroclastites similar to those known in the Lavasen Formation.

***Ambo Sector*:** The Ambo Group here presents a characteristic variation in lithofacies (Zapata et al., 2004). The following features are recognized: 1) A conglomerate member (Buena Vista Formation, lower member) is overlain by 2) alternation sandstones and shales (Buena Vista Formation, upper member) with abundant fauna (*Schewienella australis* Thomas, *Punctospirifer* cf. *P. subtexta* White, *Verkhotomia jucunda* Carter, *Rugosochonetes* cf. *R. obtectus* Roberts, *Punctospirifer sabricostus* North, *Cleiothyridina* cf. *C. tenuilineata* Rowley), which gradually passes to 3) a succession of sandstones, siltstones and micaceous shales (Formation Yanaj) with abundant flora (where dominate *Cyclostigma pacifica* Steinmann, *Lepidodendronis lissoni* Steinmann, *Shenopteris paracasica* Ghotan), and 4) conglomeratic sandstones interbedded with rhyolitic tuffs (Chunomaja Formation).

***Junin-Huancavelica Sector*:** Here the Ambo Group consists of a succession of conglomerates, sandstones and shales intercalated with rhyolithic tuffs in its upper part. Its thickness varies from a few metres northeast of Junín to 600 m in the Raushanca area (Mégard et al., 1996). A similar succession occurs in Huanta. Near Acobamba, northeast of Huancavelica, deposits produced by explosive volcanism occur in the upper Ambo Group (Romero et al., 2002). The local fossil flora and fauna places this intra-arc sedimentation in the Tournaisian to lower Serpukhovian interval. The paleoenvironment ranged from alluvial fans to deltas prograding in a siliciclastic shelf; these transgressive deposits are overlain by a regressive succession deposited in channels and flood plains of a fluvial paleoenvironment, with intercalations of pyroclastic levels and lava flows.

BACK-ARC BASIN: A coeval foreland-type basin extended in the Altiplano and Subandean Belt of Peru and Bolivia, west of the Brazilian Shield (Sempere, 1989; Díaz, 1995; Isaacson and Díaz, 1995). The stratigraphic succession in this basin included: 1) diamictites and interbedded sandstones and conglomerates (Cumaná Formation), overlain by 2) sandstones and shales, with intercalations of conglomerates (Siripaca Formation), and 3) shales and sandstones with coal intercalations which yielded an abundant paleoflora including *Tomiodendron* sp., *Nothorhacopteris kellaybelensis*, *Diplothmema* cf. *D. bodenbenderi*, *Triphyllopteris boliviana*, stems of Lycophyta and fructifications of Pteridospermophyta (Iannuzzi et al., 1998). Unit 1 was deposited in a glaciomarine paleoenvironment; unit 2 reflects progradation of deltaic systems in a shallow wave- and storm-dominated siliciclastic shelf, whereas unit 3 was deposited in a deltaic plain and distal alluvial system of high sinuosity (Diaz, 1991).

CONCLUSIONS AND DISCUSSION

The Lower Carboniferous sedimentation occurred simultaneously in three types of basin: 1) in the fore-arc, continental deposition was dominant (late Visean– early Serpukhovian record); 2) intra-arc basins received

marine and continental sedimentation (Tournaisian – early Serpukhovian record); 3) in the back-arc, glaciomarine sedimentation was followed by marine and continental sedimentation (late Famennian – early Serpukhovian record). Subsidence was apparently greater during the Visean in the intra-arc basins, where the Lavasen volcanics interfingered with the continental upper Ambo Group, similarly to the Visean volcanism described by Roberts et al. (1993) in Australia. In northern Peru, the volcanic rocks that underlie the limestones of the Pennsylvanian-Lower Permian Tarma-Copacabana Group should be mid-Carboniferous in age. Arc magmatism, however, lasted at least from the latest Devonian to the Early Permian plutonism, as evidenced by the mentioned 1000 km-long plutonic belt.

References

Alleman, V. y Pferfferkorn, H. (1988) – Licópodos de Paracas: significado geológico y paleoclimatológico. Bol. Soc. Geol. Perú, 78, p. 131-136.

Alleman, V. (1991) – Presencia de Myaliniidae (Mollusca Bivalvia) en la serie carbonífera de Paracas (Pisco – Depto. De Ica). VII Congreso Peruano de Geología (Lima). p 399-400.

Alleman, V., Pferfferkorn, H. y Erwin, D. (1995) – Los contextos paleoecológicos variados de las floras carboníferas de Paracas (Ica-Perú). Bol. Soc. Geol. Perú, v. 84, p 37-42.

Alemán y León (2002) - Un arco volcánico Mississipiano adyacente a la cordillera de la costa. S.G.P. P.4.

Bonhome. (1985) - Nuevas Edades K/Ar Cenozoicas, de rocas volcánicas de la Cordillera de los Andes, Sureste del Perú, Comunicaciones (25):33. Departamento de Geología de la Universidad de Chile (1985).

Cardona, A. (2005) - Tesis Doctoral en preparación. Post-graduando de la Universidad de Sao Paulo-Brasil.

Dalmayrac, B., Laubacher, g., Marocco, R. (1988) – Caracteres Generales de la Evolución Geológica de los Andes Peruanos. Bol. 12, Serie D.

Díaz, E., (1991) - Litoestratigrafía del Carbonífero del altiplano de Bolivia. Revista Técnica de YPFB, 12 (2): 295 – 302.

Díaz, E. (1995) - Regional Correlations with Late Paleozoic events in Bolivia. 2° Simp. Cronoestratigrafía Cuenca de Paraná, Porto Alegre. Bol. Resumos Expandidos, 245-247.

Haeberlin Y. et al. (2002) - Geological and structural setting, age, and geochemistry of the orogenic gold deposit at the Pataz Province, Eastern Andean Cordillera, Peru. Genève Université. Département de Minéralogie 182 p.

Martínez, M. (1970) – Geología del basamento Pelozoico en las Montañas de Amotape y posible origen de Petróleo e rocas Paleozoicas del Noroeste del Perú. I Congreso Latinoamericano de Geología.

Mégard F. (1979) - Estudio geológico de los Andes del Perú Central. Perú. Bol. N° 8, Serie D, 227p.

Mégard F., Caldas, J., Paredes, J., De la Cruz N., (1996) - Geología de los Cuadrángulos de Tarma, La Oroya, Yauyos. INGEMMET. Bol. N° 69 Serie A: Carta Geológica Nacional. 279 p.

Nuñez Del Prado, H. (1991) – Análisis Sedimentológico preliminar y Paleoambiente de Sedimentación de la serie carbonífera de Paracas (Ica-Perú). VII Congreso Peruano de Geología (Lima), p. 45-48.

Iannuzzi, R., Pfefferkorn, H., Díaz, E. Alleman, V. y Suarez, R. (1998) – La Flora Eocarbonífera de la Formación Siripaca (Grupo Ambo, Bolivia) y su correlación de la Flora de Paracas (Grupo Ambo, Perú). Bol. Soc. Geol. Perú, 88 (1998) p. 39-51.

Isaacson, P. E., and Díaz, E. (1995). Evidence for a Middle-Late Paleozoic foreland basin and significant latitudinal shift, Central Andes. AAPG Memoir, 62, 231-249.

Lancelot, J. R., Laubacher, G., Marocco, R. and Renaud, U. (1978) - U/Pb radiochronology of two granitic plutons from the Eastern Cordillera (Perú). Extend of Permian magmatic activity and consequences. Geol. Rundsch., 67(1), pp. 236-243.

Palacios, O. (1994) - Geología de los cuadrángulos de Paita, Piura, Talara, Sullana, Lobitos, Quebrada Seca, Zorritos, Tumbes y Zarumilla INGEMMET. Bol. N° 54, Serie A: Carta Geológica Nacional. 190 p.

Pino A. et al. (2004) - Estratigrafía, paleogeografía y paleotectónica del intervalo Paleozoico Superior – Cretáceo Inferior en el área de Mal Paso – Palca (Tacna). Soc .Geol. Perú. Publicación especial N° 5, pp. 15 - 44.

Romero, D. y Torres, V. (2002) – Actualización de la Geología del cuadrángulo de Huancavelica. Escala 1:100,000. INGEMMET (en prensa).

Roberts, J., Claoué-Long, J. and Jones, P. J. (1993). Revised correlations of Carboniferous and Early Permian units of the Southern New England Orogen, Australia. Carboniferous Newsletter, 11, 23-26.

Sánchez, A. (1995) - Geología de los Cuadrángulos de Bagua Grande, Jumbilla, Lonya Grande, Chachapoyas, Rioja y Leimebamba. INGEMMET. Bol. N° 56 Serie A: Carta Geológica Nacional. 400p.

Sánchez, A., Carrasco, S., y Zapata, A. (2005) - Magmatismo durante el Carbonífero en los Andes Peruanos. XII Congreso Latinoamericano de Geología.

Schreiber, D. W., Fontboté, L. and Lochmann, D. (1990) - Geologic setting, paragenesis, and physicochemistry of gold quartz veins hosted by plutonic rocks in the Pataz region. Econ. Geol. Vol. 85., pp. 1328-1347.

Sempere, T. (1989) - Paleozoic Evolution of the Central Andes (10-26°S). 28th Int. Geol. Congr., Washington D.C.. Abstracts., 3, 73.

Vidal, C. E., Paredes, J., Macfarlane, A. W. y Tosdal, R. M., (1995) - Geología y Metalogenia del Distrito minero Parcoy, Provinvcia Aurífera de Pataz, La Libertad. Volumen Jubilar Alberto Benavides. Sociedad Geológica del Perú. pp. 351-377.

Zapata, A.; Rossel, W.; Sánchez, A.; y Aldana, M., (2004) - División del Grupo Ambo en su localidad tipo (Tournaisiano - Viseano). XII Congreso Peruano de Geología, Resúmenes Extendidos. pp 560-563.

Zapata, A., Sánchez, A., A., Carrasco, S., Galdos, J., y Cerrón, F., (2005) - Litoestratigrafia y Distribucion del Carbonífero Inferior entre Molino – Pataz – Ruibarbos y su correlación regional en el borde occidental de Gondwana. XII Congreso Latinoamericano de Geología.PAPPMGM