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Palynology of the Iscayachi Formation (Cambro-Ordovician) from the Cordillera Oriental of Southern Bolivia: New data from the western margin of Gondwana

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ABSTRACT

The first late-Cambrian aged palynomorph assemblage of Bolivia is presented. The sampled material comes from the Cambro-Ordovician Iscayachi Formation cropping out in the Antenna of the Sierra de Sama, Tarija department, southern Bolivia. The palynomorph assemblage occurs in levels correlated to the *Parabolina* (*Neoparabolina*) *frequens argentina* trilobite biozone. It is comprised of *Acanthodiacrodium* spp., *Cristallinium cambriense*, *Cymatiogalea* cf. *C. aspergillum*, *C. velifera*, *C. virgulta*, *Dasydiacrodium* spp., *Eliasum llaniscum*, *Impluviculus multiangularis*, *Ladogella rommelaerei*, *Ladogella* sp., *Leiofusa* sp., *Leiosphaeridia* sp., *Lophosphaeridium* sp., *Lusatia?* sp., *Micrhystridium* sp., *Poikilofusa squama*, *Poikilofusa* sp., *Polygonium dentatum*, *Retisphaeridium brayense*, *Saharidia fragilis*, *Solisphaeridium akrochordum*, *S. lucidum*, *Timofeevia phosphoritica*, *Timofeevia microretis*, *Vulcanisphaera africana* and *V. turbata*. The assemblage provides elements of comparison with previously reported palynofloras in northern Argentina, eastern Newfoundland, southwestern Sardinia, Algeria, northern Spain, Baltica and Avalonia (Arctic Russia, East-European Platform). All microphytoplancton are indicative of cold water affinities as expected from the western margin of Gondwana, showing some Baltic affinities as well.

KEYWORDS **Reservoir analogue. GPR. ERT. Delta sandstones. Eocene. South-pyrenean foreland basin.**

INTRODUCTION

Thick siliciclastic sequences assigned to the Cambro-Ordovician transition are widely distributed along the South American Andean margin. These sequences have been studied in different geological aspects during the last 100 years, with special references to their outstanding paleontological content (*e.g.* D'Orbigny, 1842; Forbes 1861; Kayser, 1876; Steinmann and Hoek, 1912; Ahlfeld and Branisa, 1960).

Remarkable sedimentary packages, with thicknesses that reach up to more than 1000 meters for the Cambro-Ordovician transition in the Cordillera Oriental of southern Bolivia, are a permanent source of new fossil findings that contribute to a better understanding of the transition between the Cambrian and Ordovician. The present knowledge of these strata and their paleontological heritage is acceptable, with an important amount of data added especially during the last 20 years (*e.g.* Suárez Soruco, 1976; Erdtmann *et al.*, 1995; Maletz *et al.*, 1995; Aceñolaza *et al.*, 1996; Egenhoff, 2003). However, most paleontological investigations have been focused on macrofossils, so that microfossils have been largely overlooked in the Bolivian Cambro-Ordovician literature.

This contribution presents the first palynological assemblage of the Cordillera Oriental of Bolivia, providing new elements that will contribute to the analysis of the biostratigraphical succession in the western margin of Gondwana. The new data allows a more precise dating and correlation of sequences with other reference sections in the Lower Paleozoic Andean basins (Rubinstein *et al.*, 2003; Aráoz y Vergel, 2006; Vergel *et al.*, 2007).

GEOLOGICAL SETTING, STRATIGRAPHICAL AND BIOSTRATIGRAPHICAL FRAMEWORK

The palynomorph assemblage was recovered from grayish shales belonging to the middle sector of the Iscayachi Formation, cropping out at the Antenna locality, in the upper part of the Sierra de Sama (Tarija Department, southern Bolivia) (Fig.1).

Sampling was performed in a section displaying well-preserved shelly fossils on the road between Tucumillas and Iscayachi (Fig. 1). This section has been analyzed several times, and has become a classic outcrop of the southern sector of the Bolivian Cordillera Oriental. Surprisingly, despite its potential for microfossil content, no palynological analyses have been attempted previously. Among some classical papers dealing with the area we shall mention Ahlfeld and Branisa, (1960); Rivas *et al.,* 1969; Justiniano, 1972; Wende, 1972; Avila, 1972; Suárez Soruco, 1976; Rodrigo and Castaños, 1978; Erdtmann *et al.,* 1995; Maletz *et al.,* 1995; Aceñolaza *et al.,* 1996.

The Cambro - Ordovician strata in southern Bolivia display one of the thickest sedimentary successions of the world, with more that 12.000 meters of siliciclastic rocks with very few minor carbonate intercalations (Ahlfeld and Branisa, 1960; Suárez Soruco, 1976; Erdtmann, 1996; Egenhoff *et al.*, 1998). The boundary beds between both systems are located within the 1000-1500 meters-thick shales and sandstones comprised in the Iscayachi Formation (Rivas *et al.*, 1969; Erdtmann *et al.*, 1995). The greenish-grayish sandstones and shales of the Iscayachi Formation (Rivas *et al.*, 1969) overlies the whitish and pinkish quartzites of the Sama Formation (Ahlfeld and Branisa, 1960).

Detailed sedimentary analysis in the Iscayachi formation allowed to interpret it as deposited on a shoreface setting, varying between an upper offshore to lower shoreface and transition to upper offshore setting. The succession displays a general deepening of facies, from intertidal to subtidal storm- and wave-dominated paleoenvironment (Erdtmann *et al.*, 1995; Aceñolaza *et al.*, 1996). Discrete to highly bioturbated strata with lenticular intercalations of cross-bedded sandstones are recorded in the sequence. Monotaxic (brachiopods) and bitaxic (brachiopod/trilobites) coquinas occur locally, with fragmentary material assigned to *Jujuyaspis keideli, Parabolina* (*N.*) *frequens argentina* and the brachiopod *Apheorthis samensis* (Suárez Soruco, 1975; 1992).

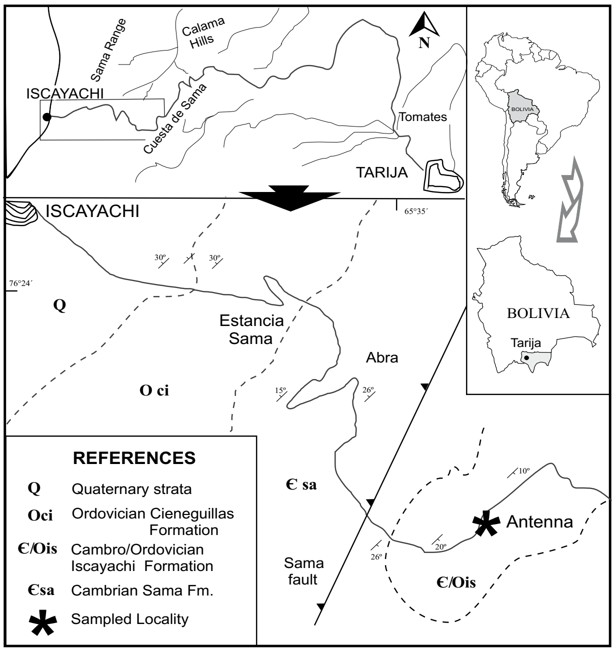

FIGURE 1 | Geological map of the investigated locality in Sama Range, Tarija Departament, southern Bolivia.

Trilobites, brachiopods and graptolites are frequently recorded all along the sequence, being included in the *Parabolina* (*N.*) *frequens argentina* trilobite biozone of Cambro-Ordovician age (Harrington and Leanza, 1957; Pribyl and Vanek, 1980; Suárez Soruco, 1992). All occurrences of *Rhabdinopora* sp. are found in the upper part of the unit. Minor bands of sandstones with rhabdinoporid graptolites and trilobite coquinas define the top of the unit, this level has been considered to be equivalent to the lowstand part of the Black Mountain Eustatic Event of Miller, 1984 (Erdtmann, *et al.*, 1995). Graptolite fauna denotes an intermediate paleolatitudinal position of the area, similar to the coeval graptolite fauna of the outer shelves of the Oslo Scania Confacies (Erdtmann *et al.*, 1995).

The Cambrian - Ordovician boundary has been previously identified in the upper Iscayachi Formation, within the transgressive succession, at the first appearance datum (FAD) of *Rhabdinopora* (Erdtmann *et al.*, 1995).

The top of the Iscayachi Formation displays a sharp contact between cherty dark shales and sandstones with mass occurrences of *Rhabdinopora* sp. (Erdtmann *et al.*, 1995; Erdtmann, 1996), that are followed upwards by the almost 3000m-thick shalier Cieneguillas Formation (Rivas *et al.*, 1969).

PALYNOLOGICAL DATA

Material and methods

Six samples for palynological analysis were collected from fine-grained siliciclastic deposits. Only two, separated a few meters (5m), yielded palynomorphs. These levels are located at the middle sector of the Iscayachi Formation (Fig. 2). The samples (ca. 30g) were processed using standard palynological methods involving maceration of sediments with hydrochloric and hydrofluoric acids. Neither oxidative nor alkali treatments were applied. The organic residue was sieved with a 10μm screen and was mounted on slide for optical study using transmitted light microscopy. The slides, prefixed Instituto Superior de Correlación Geológica Pl, are held at the Palynological Collection of the Instituto Superior de Correlación Geológica (INSUGEO, Tucumán) and the figured specimens have the England Finder coordinates.

The samples yielded a poorly preserved and diverse assemblage, consisting principally of acritarch and prasinophyte species. The specimens have a high degree of thermal alteration and are damaged by pyrite crystallization. Amorphous organic matter is abundant in both samples.

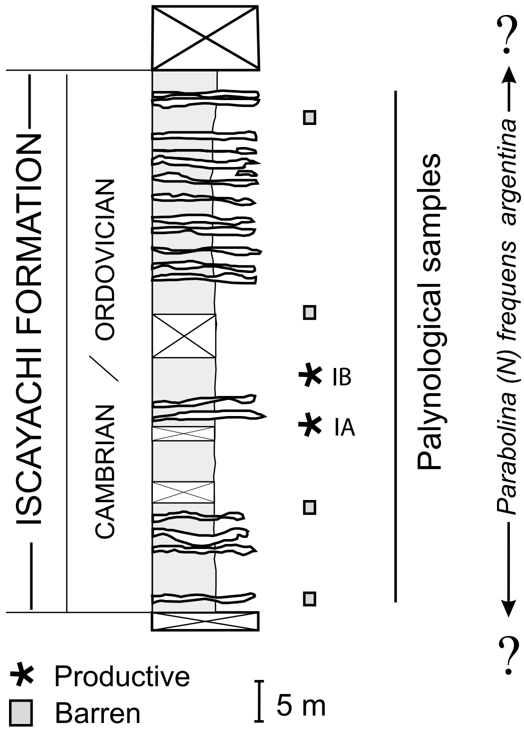

FIGURE 2 | Stratigraphic section of the Iscayachi Formation (Cambro-Ordovician) at Antenna locality, Sama Range, Southern Bolivia. Location of sampled levels with reference of productive (IA, IB) and barren samples.

Description and stratigraphic significance of the assemblage

In the lowermost sample (IA) the preservation of organic-walled microfossils is poor, and only undeterminable acanthomorphs, some galeate acritarchs and leiospheres were observed. The uppermost sample (IB) contains better preserved and identifiable specimens, which are described herein.

The taxa identified in the IB sample are listed below in alphabetical order and the most representative are illustrated in Figures 3 and 4. The assemblage consists of *Acanthodiacrodium* spp., *Cristallinium cambriense* (Slavíková, 1968) Vanguestaine, 1978; *Cymatiogalea* cf. *C. aspergillum* Martin in Martin and Dean, 1988; *C. velifera* (Downie, 1958) Martin, 1969; *C. virgulta* Martin in Martin and Dean, 1988; *Dasydiacrodium* spp., *Eliasum llaniscum* Fombella, 1977; *Impluviculus multiangularis* (Umnova in Umnova and Fanderflit, 1971) Volkova, 1990; *Ladogella rommelaerei* (Martin, 1981; in Martin and Dean, 1981) Di Milia, Ribecai, Tongiorgi, 1989; *Ladogella* sp., *Leiofusa* sp., *Leiosphaeridia* sp., *Lophosphaeridium* sp., *Lusatia?* sp., *Micrhystridium* sp., *Poikilofusa squama* (Deunff, 1961) Martin, 1977; *Poikilofusa* sp., *Polygonium dentatum* (Timofeev, 1959) Albani, 1989; *Retisphaeridium brayense* (Gardiner and Vanguestaine, 1971) Moczydlowska and Crimes, 1995; *Saharidia fragilis* (Downie, 1958) Combaz, 1967; *Solisphaeridium akrochordum* (Rasul, 1979) Moczydlowska and Stockfords, 2004; *S. lucidum* (Deunff, 1959) Turner, 1985; *Timofeevia phosphoritica* Vanguestaine, 1978; *Timofeevia microretis* Martin in Martin and Dean, 1981; *Vulcanisphaera africana* Deunff, 1961; and *V. turbata* Martin in Martin and Dean, 1981.

The most abundant taxa (between 25 and 10 specimens observed) are *Cymatiogalea velifera*, *Cristallinium cambriense*, *Impluviculus multiangularis*, *Poikilofusa squama*, *Poikilofusa* sp. and *Vulcanisphaera* (*V. africana* and *V. turbata*). They occur in association with the following less abundant species (between 10 and 5 specimens observed): *Ladogella* spp., *Saharidia fragilis*, and *Solisphaeridium lucidum*. Also present but less abundant (between 5 and 2 specimens observed) are *Eliasum llaniscum*, *Polygonium dentatum*, *Retisphaeridium brayense*, *Timofeevia microretis* and *T. phosphoritica*. The genera *Leiofusa*, *Leiosphaeridia*, *Lophosphaeridium* and *Micrhystridium* occur more rarely. It is important to mention that several unidentified species of *Acanthodiacrodium* and *Polygonium* are present, together with undeterminable palynomorphs such as the specimens displayed in Figure 4L.

Most of the taxa listed above are known to occur worldwide in Cambrian and Ordovician stratal sequences. Some of them are biostratigraphically significant, and allow for a reliable correlation and estimation of the relative age of the sampling level.

Species ranging across the Cambrian-Ordovician transition are: *Cristallinium cambriense*, *Cymatiogalea velifera*, *Ladogella rommelaerei*, *Poikilofusa squama*, *Polygonium dentatum*, *Saharidia fragilis*, S*olisphaeridium lucidum* and *Vulcanisphaera africana* (Martin and Dean, 1988; di Milia *et al*., 1989; Vecoli, 1996; 1999; Vanguestaine, 2002; Aráoz and Vergel, 2006; Vergel *et al*., 2007).

Several *Cymatiogalea* species have proved significant to date the acritarch assemblages (Servais *et al*., 2004). This genus first appears in the lowest Furongian (Martin and Dean, 1981; 1988; Volkova, 1990, Vecoli, 1996; 1999) and ranges into the Early Ordovician (Servais *et al*., 2004). However, *C. virgulta* and *C. aspergillum* have their highest record towards the Upper Cambrian of the *Peltura* and *Acerocare* trilobite zones, respectively (Martin and Dean, 1988; Vecoli, 1996). *Impluviculus multiangularis* makes its first appearance in the *Peltura* trilobite Zone (Parsons and Anderson, 2000), and *Vulcanisphaera turbata* appears in the Middle Cambrian (Martin and Dean, 1981). These two species do not extend their stratigraphic range into the Upper Cambrian (Parsons and Anderson, 2000).

Eliasum llaniscum has a worldwide paleogeographic distribution in the Middle and Upper Cambrian (Molyneux *et al*., 1996), but most commonly occurs in the Middle Cambrian. Recently, Moczydlowska *et al.,* 2004; Moczydlowska and Stockfors, 2004; extended its stratigraphic range into the Early Tremadocian. However, Palacios et at., 2009; provides new age constraints on *E. llaniscum* in its type area, considering the upper range of undoubted *E. llaniscum* to be within the upper A2 Zone of Martin and Dean, 1988; and VK1 of Volkova, 1990; corresponding to the Middle Cambrian - Lower Furongian.

Retisphaeridium brayense and *Timofeevia phosphoritica* make their appearance in the Middle Cambrian (Moczydlowska and Crimes, 1995; Vecoli, 1996); and stratigraphically extend (Moczydlowska and Crimes, 1995; Vecoli, 1996; Parsons and Anderson, 2000) into the Upper Cambrian (*Parabolina* Fauna and *Peltura* trilobite zones respectively). *Timofeevia microretis* has also been recorded only in Upper Cambrian successions (Martin and Dean, 1981; Vecoli, 1996).

Lusatia dendroidea (Burmann, 1970); Albani, Bagnoli, Bernández, Gutiérrez-Marco and Ribecai, 2007; has a widespread paleogeographic distribution, and was recently proposed as an excellent guide fossil for the Furongian (*Leptoplastus* and *Peltura-Acerocare* trilobite zones). In the present study, specimens of *Lusatia* sp. have been recorded which may possibly be cospecific with *L. dendroidea*, thus potentially providing additional age control for the assemblage, confirming a late Cambrian age.

Poikilofusa squama has been recorded from Cambrian and Ordovician successions (Parsons and Anderson, 2000); however, several specimens recognized in the Iscayachi assemblage may be assigned to *Poikilofusa* sp. A of Parsons and Anderson, 2000; occurring in Upper Cambrian successions from Newfoundland, Canada (Parsons and Anderson, 2000; with references to Wales and Estonia) and Spain (Albani *et al*., 2006).

Recently, a study has been published by Vecoli *et al.,* 2008; in which middle to late Cambrian acritarch assemblages from northwestern Algeria have been described. These assemblages share some species with the Iscayachi assemblage, such as: *Eliasum llaniscum*, *Timofeevia phosphoritica*, *Cristallinium cambriense*, and species of *Acanthodiacrodium*, and *Dasydiacrodium* which are similar to the Iscayachi assemblage.

According to the above discussion, it seems reasonable to assume that the age of the present assemblage is not older than the late Cambrian (Furongian), equivalent to the *Peltura* trilobite zone. The presence of *Cymatiogalea virgulta*, *Timofeevia phosphoritica* and *V. turbata*, all showing their highest record in the Upper Cambrian, in addition to the known lowest occurrence of *Ladogella rommelaerei*, *Impluviculus multiangularis* and *Saharidia fragilis* support this age determination. Moreover, the absence of any diagnostic taxa of Tremadocian age suggests a late Cambrian age for the Iscayachi assemblage.

Considering the assemblages recorded by Rubinstein *et al.,* 2003; Aráoz and Vergel, 2006; Vergel *et al.,* 2007; from the Casa Colorada Formation at Moya Creek, in the Cordillera Oriental of northern Argentina, the Iscayachi assemblage shows the highest similarity with the associations described from the middle sector of the Moya succession. These assemblages include the following species which are in common with the Iscayachi palynoflora: *Cristallinium cambriense*, *Cymatiogalea velifera*, *Lusatia?* sp., *Polygonium dentatum*, *Saharidia fragilis*, *Timofeevia phosphoritica*, *Vulcanisphaera africana* and *V. turbata*.

In addition, the Iscayachi assemblage is correlative to associations from West Gondwana such as northern Sahara: *Timofeevia phosphoritica-Dasydiacrodium caudatum* assemblage zone from Vecoli, 1999; northern Spain: association from El Fabar beds, Albani *et al*., 2006; southwest Sardinia in Italy: assemblage from the Arburese

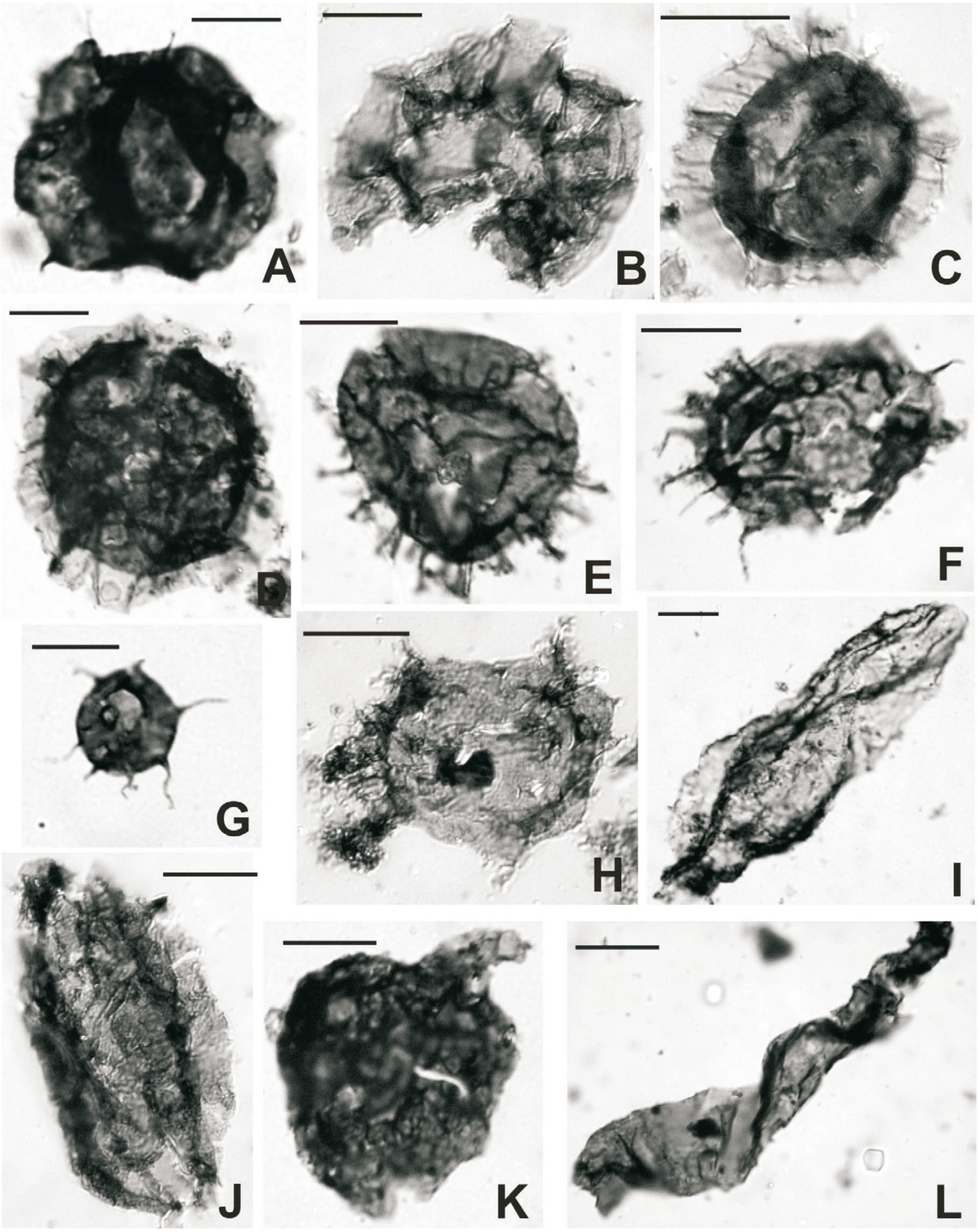

FIGURE 3 | A) Acanthodiacrodium sp. (Instituto Superior de Correlación Geológica Pl IB-6, 27O2); B) Cristallinium cambriense (SLAVIKOVÁ, 1968) VANGUESTAINE, 1978 (Instituto Superior de Correlación Geológica Pl IB-7, 44S3); C) Cymatiogalea cf. C. aspergillum MARTIN in MARTIN and DEAN, 1988 (Instituto Superior de Correlación Geológica Pl IB-7, 46L); D) Cymatiogalea velifera (DOWNIE, 1958) Martin, 1969 (Instituto Superior de Correlación Geológica Pl IB-7, 52H3); E) Cymatiogalea virgulta MARTIN in MARTIN and DEAN 1988 (Instituto Superior de Correlación Geológica Pl IB-8, 38U3); F) Dasydiacrodium sp. (Instituto Superior de Correlación Geológica Pl IB-5, 30Z); G) Impluviculus multiangularis (UMNOVA in UMNOVA and FANDERFLIT, 1971) VOLKOVA, 1990 (Instituto Superior de Correlación Geológica Pl IB-4, 39L); H) Ladogella rommelaerei (MARTIN in MARTIN and DEAN, 1981) DI MILIA, RIBECAI, TONGIORGI, 1989 (Instituto Superior de Correlación Geológica Pl IB-6, 45C4); I) Poikilofusa squama (DEUNFF, 1961) MARTIN, 1977 (Instituto Superior de Correlación Geológica Pl IB-1, 45C4); J) Eliasum llaniscum FOMBELLA, 1977 (Instituto Superior de Correlación Geológica Pl IB-5, 41R3); K) Lusatia? sp. (Instituto Superior de Correlación Geológica Pl IB-5, 51C3); L) Leiofusa sp. (Instituto Superior de Correlación Geológica Pl IB-5, 27L). Scale bars: 10µm.

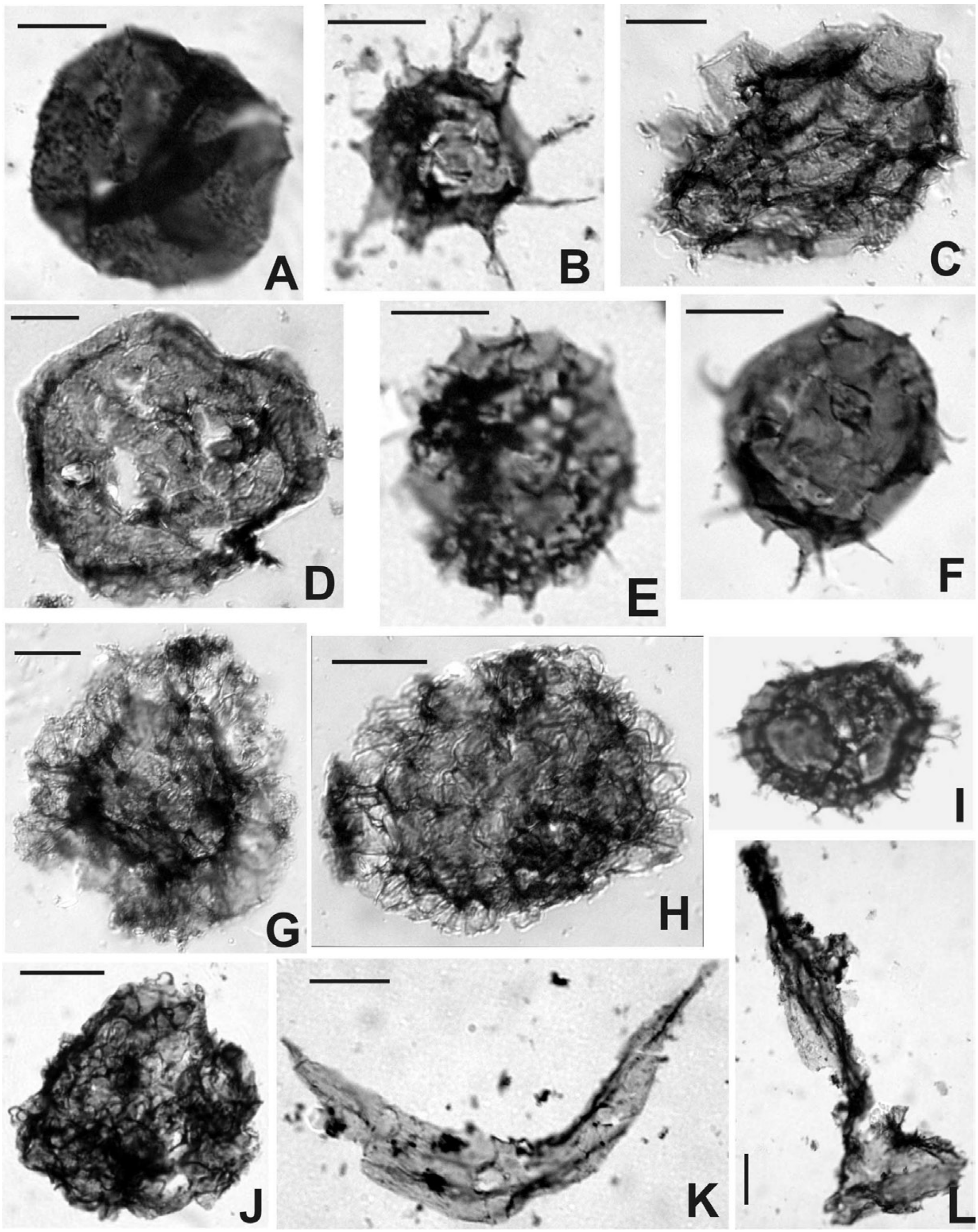

FIGURE 4 | A) Lophosphaeridium sp. (Instituto Superior de Correlación Geológica Pl IB-5, 35O); B) Polygonium dentatum (Timofeev, 1959) Albani, 1989 (Instituto Superior de Correlación Geológica Pl IB-6, 46M); C) Retisphaeridium brayense (Gardiner and Vanguestaine, 1971) Moczydlowska and Crimes, 1995 (Instituto Superior de Correlación Geológica Pl IB-6, 47R1); D) Saharidia fragilis (Downie, 1958) Combaz, 1967 (Instituto Superior de Correlación Geológica Pl IB-3, 43K); E) Solisphaeridium akrocordum (Rasul 1979) Moczydlowska and Stockfors 2004 (Instituto Superior de Correlación Geológica Pl IB-5, 30G); F) Solisphaeridium lucidum (Deunff, 1959) Turner, 1985 (Instituto Superior de Correlación Geológica Pl IB-1, 53M2); G) Timofeevia microretis Martin in Martin and Dean, 1981 (Instituto Superior de Correlación Geológica Pl IB-6, 44D3); H) Vulcanisphaera africana Deunff, 1961 (Instituto Superior de Correlación Geológica Pl IB-3, (51B1); I) Timofeevia phosphoritica Vanguestaine, 1978 (Instituto Superior de Correlación Geológica Pl IB-4, 57N); J) Vulcanisphaera turbata Martin in Martin and Dean, 1981 - (Instituto Superior de Correlación Geológica Pl IB-3, 48B3); K) Poikilofusa sp. (Instituto Superior de Correlación Geológica Pl IB-6, 30D); L) Undetermined palynomorph (Instituto Superior de Correlación Geológica Pl IB-1, 54F). Scale bars: 10µm.

area, Ribecai *et al.,* 2005; Baltica (Volkova, 1990; Kolguev Island - Artic Russia: Moczydlowska *et al*., 2004; Moczydlowska and Stockfors, 2004; Assemblage IV from Severnaya Zemlya - Rusia: Raevskaya and Golubkova, 2006); Avalonia (Eastern Newfoundland: Assemblage A5 of Martin in Martin and Dean, 1981; 1988; Assemblage RA5 of Parsons and Anderson, 2000); southern Iran: Zone IV of Ghavidel-Syooki and Vecoli, 2008.

Several taxa characteristic of the above mentioned assemblages are in common with the Iscayachi association, among which the most representative are: *Cymatiogalea* cf. *aspergillum*, *Impluviculus multiangularis*, *Lusatia?* sp., *Timofeevia microretis*, *T. phosphoritica* and *Vulcanisphaera turbata*, all of them restricted to the late Cambrian assemblages.

In Cambrian times, South America was located on tropical paleolatitude in the western margin of Gondwana (McKerrow and Scotese, 1990). Particularly the assemblage of the Iscayachi Formation is comparable to similar sets that have been recorded in North Africa, Avalonia and South Iran, all of them representing a cool to cold water microphytoplancton biogeographic realm.

CONCLUSIONS

The first palynological (acritarch and prasinophytes) assemblage is described from the Iscayachi Formation cropping out in the southern sector of the Cordillera Oriental of southern Bolivia. The assemblage is composed by distinctive taxa such as *Impluviculus multiangularis*, *Lusatia?* sp., *Timofeevia phosphoritica* and *Vulcanisphaera turbata* indicatives of a late Cambrian age. Associated fauna includes trilobites of the *Parabolina (N.) frequens argentina* biozone as well as linguliform brachiopods.

The assemblage denotes notorious paleogeographical implications for Lower Paleozoic basins of northern and western Gondwana. It represents the first record of late Cambrian acritarchs from Bolivia, and complements the Argentine references from the Lower Paleozoic Central Andean Basin. Data can be correlated with the northern Sahara, northern Spain, southwest Sardinia, Baltica, the Severnaya Zemlya region from Russia and eastern Newfoundland; characterizing a time of limited diversification prior to "The Great Ordovician Biodiversification Event" (Webby *et al*., 2004).

TAXONOMICAL NOTES

GENUS *Acanthodiacrodium* Timofeev, 1958; emend. Deflandre and Deflandre-Rigaud, 1962.

Type species. *Acanthodiacrodium dentiferum* Timofeev, 1958.

Acanthodiacrodium sp.
Fig. 3A

Description. Vesicle subcircular to sub-quadrangular in outline with a narrow equatorial zone. Eilyma smooth. Ten to 15 processes on each pole with a dome-like base, homomorphic, slender, simple and distally tapering to a fine termination.
Dimensions. Vesicle length 28-36μm, vesicle width 26-32μm, processes length 3-6μm.
Number of specimens observed. 9 specimens.
Remarks. *Acanthodiacrodium golubii* Fensome, Williams, Sedley Barss, Freeman, Hill 1990; is the most similar species, differing only for its equatorial striations and the spiny/branched distal termination of the processes.

GENUS *Cymatiogalea* Deunff, 1961; emend. Deunff, Gorka, Rauscher, 1974

Type species. *Cymatiogalea margaritata* Deunff, 1961.
Cymatiogalea cf. C. aspergillum Martin in Martin and Dean, 1988.

Cymatiogalea sp.
Fig. 3C

Description. Vesicle circular to polygonal in outline with psilate wall. Cylindrical and hollow processes (25 to 38 in number), not communicating with vesicle interior, frequently bifurcate at the distal extremities and supported by a transparent psilate membrane.
Dimensions. vesicle diameter 24-31μm, number of polygonal fields 6-8, number of processes at each side of polygonal fields 3-4, length of processes 5-7μm.
Number of specimens observed. 16 specimens.
Remarks. *C. aspergillum* differs from the present specimens by having digitate, not totally branched process extremities.

GENUS *Dasydiacrodium* Timofeev, 1959; emend. Moczydlowska and Stockfors, 2004

Type species: Dasydiacrodium eichwaldii Timofeev 1959. By subsequent designation of Deflandre and Deflandre-Rigaud, 1962.

Dasydiacrodium sp.
Fig. 3F

Description. Vesicle sub-circular to ovoid, asymmetric with rounded polar areas. Eilyma and process wall psilate. Few processes (4-7) on the apical pole, and more numerous on the antiapical pole (10-14). The processes are conical with curved proximal contact and slim distal portions.

Dimensions. Vesicle length 24-38μm, vesicle width 21-36μm, process length 12-16μm.
Number of specimens observed. 8 specimens.
Remarks. This form shows some resemblance with *Dasydiacrodium* sp. A described by Moczydlowska and Stockfors (2004), only differing from it by the longer processes of the Russian specimens.

GENUS *Lusatia* BURMANN, 1970

Type species. *Lusatia dendroidea* BURMANN, 1970; emend. ALBANI, BAGNOLI, RIBECARI, RAEVSKAYA, 2007.

Lusatia? sp.
Fig. 3K

Description. Vesicle sub-circular to sub-triangular in outline with a variable thin to thick (dark) psilate wall. The vesicle bears one, or exceptionally two incomplete processes, they are simple, hollow, freely communicating with the vesicle interior. Some specimens have a split or opening interpreted as excystment by median split.
Dimensions. Vesicle length 24-38μm, vesicle width 21-36μm, process length 12-16μm.
Number of specimens observed. 5 specimens.
Remarks. The presence of incomplete forms hinders the taxonomical designation, thus the specimens are left in open nomenclature. However, according with the recent emendation by Albani *et al.,* 2007; of the genus *Lusatia*, and in consideration to the large intraspecific variability stated, the Iscayachi specimens are considered closely equivalent to *L. dendroidea* Burmann, 1970 emend. Albani *et al.,* 2007.
Previous records. Upper Cambrian East European Platform (Volkova, 1990); northern France (Ribecai and Vanguestaine, 1993); eastern Newfoundland (Parsons and Anderson, 2000); northern Spain (Albani *et al*., 2006; 2007); southern Iran (Ghavidel-Syooki and Vecoli, 2008).

GENUS Poikilofusa Staplin, Jansonius, Pocock, 1965

Type species. *Poikilofusa spinata* STAPLIN, JANSONIUS, POCOCK, 1965.

Poikilofusa sp.
Fig. 4K

Description. Vesicle fusiform in outline, elongated, narrow and constricted towards the distal end forming vague processes. Wall ornamented with micro-granules longitudinally arranged or with a longitudinal striate ornamentation.
Dimensions. vesicle length 78-140μm, vesicle width 19-36μm.
Number of specimens observed. 4 specimens.
Remarks. *Poikilofusa* sp. is very similar to *Poikilofusa* sp. A from Parsons and Anderson, 2000. It also resembles specimens of *Poikilofusa* sp. from the "El Fabar beds" in northern Spain (Upper Cambrian, Albani *et al*., 2006).

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