FIRST ORDOVICIAN VERTEBRATE FROM SOUTH AMERICA

by

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ABSTRACT

The first Ordovician vertebrate from South America is described from the Anzaldo Formation (Caradoc, Upper Ordovician) of Central Bolivia. It is referred to a new taxon, *Sacabambaspis janvieri* nov. gen. nov. sp., within the jawless vertebrate group Heterostraci, and displays some resemblance to both *Astraspis* and *Arandaspis*. It differs from all other known heterostracans by having very broad sensory-line grooves on the exoskeleton. Consideration of the palaeobiogeography of Ordovician vertebrates suggests that the early forms have been restricted to warm regions.

RÉSUMÉ

Le premier vertébré Ordovicien d'Amérique du Sud est décrit ; il provient de la formation Anzaldo (Caradoc) de Bolivie centrale. Il est attribué à un nouveau taxon, *Sacabambaspis janvieri* nov. gen. nov. sp., dans le groupe des Hétérostracés et présente quelques ressemblances avec *Astraspis* et *Arandaspis*. Il diffère de tous les autres hétérostracés connus par la présence de sillons sensoriels très larges sur l'exosquelette. Quelques remarques sont proposées sur la signification paléobiogéographique des Vertébrés ordoviciens ; la répartition suggère que les premiers représentants de ce groupe étaient restreints aux zones chaudes du globe.

KEY-WORDS : HETEROSTRACI, *SACABAMBASPIS*, ORDOVICIAN, LOWER CARADOC, BOLIVIA, PALAEOBIOGEOGRAPHY.

MOTS-CLÉS : HETEROSTRACI, *SACABAMBASPIS*, ORDOVICIEN, CARADOC INFÉRIEUR, BOLIVIE, PALÉOBIOGÉOGRAPHIE.

INTRODUCTION

Ordovician vertebrates are very rare and most often fragmentary. They occur mainly in the Middle Ordovician, with *Astraspis* and *Eriptychius* from North America (Denison 1967, Lehtola 1973, 1983), and *Arandaspis* and *Porophoraspis* from Australia (Ritchie & Gilbert-Tomlinson 1977). Older forms from the Cambrian and the Lower Ordovician have been recorded (Bocklelie & Fortey 1976, Nitecki & *alii* 1975, Repetski 1978, etc.), but are still of uncertain affinities. These fossils are all referred to a single group of jawless fishes, the Heterostraci, which later diversified during Upper Silurian and Devonian times.

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In this paper we describe the oldest known vertebrate from South America which is referred to the Heterostraci. The material consists of three large bone fragments from the Early Caradoc age (Upper Ordovician) Anzaldo Formation, at the locality of Sacabamba, province of Esteban Acre, department of Cochabamba, Bolivia (fig. 1).

These heterostracan fossils are associated with an invertebrate fauna composed of *Bistramia* sp.. *Lingula* sp., *Planolites* sp. and *Skolithos* sp.. *Cruzania forcifera, C. rugosa, Lingula ellipsiforme, L. lineata, L. munsteri,* and *Bistramia elegans* have been reported from elsewhere in the Anzaldo Formation (Rivas S. 1970, after original data to G.R.S.). The Anzaldo Formation is a 2000 m thick sequence of lutite and limonite. Our heterostracan fossils are apparently from the upper 300 m of this formation in a well stratified, yellowish grey lutite. The fossil level is of earliest Caradoc age (Lower Upper Ordovician). The fauna is characteristic of a marine, probably a near shore littoral and well oxygenated environment, as are most other known Ordovician vertebrates.

SYSTEMATIC STUDY

Sub Class : Heterostraci

Order and Family : indet.

Sacabambaspis nov. gen.

ETYMOLOGY :

From the name of the nearby town Sacabamba.

DIAGNOSIS :

Same as for type species.

TYPE SPECIES :

Sacabambaspis janvieri nov. gen. nov. sp.

Sacabambaspis janvieri nov. sp.

fig. 1

ETYMOLOGY :

In honour of Philippe Janvier (Muséum national d'Histoire Naturelle de Paris, Institut de Paléontologie, UA 12 du CNRS).

DIAGNOSIS :

Heterostracan agnathan, with a well developed headshield, composed of coalescent tesseral plates ornamented with denticulated tubercules. Very broad and shallow sensory-line grooves.

TYPE SPECIMEN :

MNHN-BOL.V.3282, part of a probable ventral shield (fig. 1 A-C).

TYPE LOCALITY :

Sacabamba, province Esteban Acre, department of Cochabamba, Bolivia.

TYPE LEVEL :

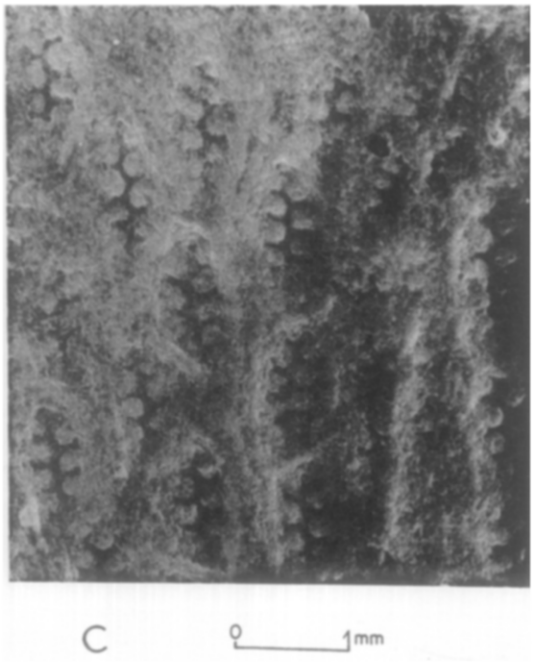
Lower Upper Ordovician (Caradoc), Anzaldo Formation.

REFERRED MATERIAL :

MNHN-BOL.V.3283, two bone fragments of the headshield.

DESCRIPTION AND REMARKS :

The holotype, which probably represents a ventral shield (fig. 1 A-B), is composed of fluoro-apatite as determined by X-ray diffraction analysis. The external structure shows numerous coalescent platelets or « tesserae », with an average size of about 5 mm. They are polygonal in shape, but irregular. Each tessera has about twelve tubercles which are denticulated and elongated as those of the Siluro-Devonian genera *Tesseraspis* and *Traquairaspis*. They differ from the stellate or smooth tubercles of *Astraspis* or *Eriptychius*, and are not regularly arranged as in *Arandaspis*. The type has a plane of symmetry which passes through an anterior median tessera, followed by a median suture on both sides of which irregular tesserae form the central part. Laterally, there is a series



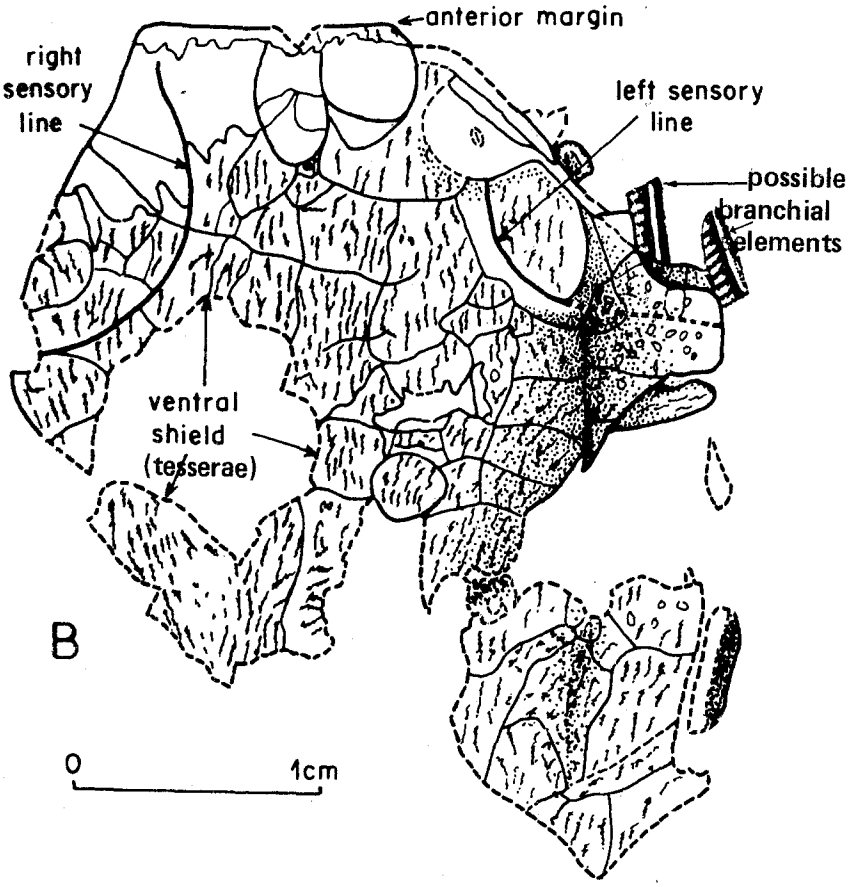


Fig. 1 — ***Sacabambaspis janvieri*** **nov. gen. nov. sp.**. A-B-holotype, MNHN-BOL.V.3282, probable ventral shield of the cephalic armour (A-photograph, B-interpretation) ; C-SEM micrograph of specimen V.3283 ; D-geographical occurence.

A-B- holotype, MNHN-BOL. V.3282, bouclier ventral probable de l'armure céphalique (A-photographie, B-interprétation) ; C-cliché au MEB du spécimen V.3283 ; D-origine géographique.

of at least four rectangular and curved tesserae which extend dorsally. The median posterior region is less clear but shows a transversely oriented ornamentation.

The tessellated structure of the shield and the detail of the tubercles of *Sacabambaspis* are most reminiscent of those of *Tesseraspis* first described from the Downton of Britain (Wills 1936). On the left side of the shield, only three fragmentary rectangular platelets are preserved (fig. 1 A-B) which might be branchial plates (?) as in *Arandaspis*. Two other bone fragments on the type are elongated in shape and bear blunty pointed spinelets producing a serrated edge ; they are located under the lateral plates and may be branchial dermal elements. Similar elements were recovered on *Arandaspis* and are considered as trunk scales (Ritchie & Gilbert-Tomlinson 1977), like those of the Silurian birkeniid anaspids. In *Eryptichius* the scales are more or less square-shaped and the serrated edge is produced by the elongated tubercles of the ornamentation. This shape of trunk scale seems to have been common among primitive agnathans.

The sensory line system is represented by two anterolateral curved grooves, which may correspond to the postoral canals of the cyathaspids (Denison 1964). However they do not continue posteriorly in our specimen, but turn laterally. *Sacabambaspis, Astraspis* and *Arandaspis* share this unusually superficial sensory line system among heterostracans. The sensory line pattern of the Bolivian species is different from that of *Arandaspis* from Australia (Ritchie & Gilbert-Tomlinson 1977).

CONCLUSION

The new Ordovician vertebrate from South America, *Sacabambaspis janvieri*, is structurally more similar to the North American forms than to the Australian ones. The structure of its shield, composed of more or less cyclomorial coalescent tesserae, is the main difference from *Arandaspis*. This structure may indicate differences in growth.

The heterostracan fossils from South America provide new information on the palaeobiogeography of the Lower Palaeozoic. Figure 2 gives two possible interpretations of the Ordovician palaeogeography, where the vertebrate records have been plotted. We immediately see the « strategic » location of the new species from Bolivia, geographically intermediate between the Australian and North American records. However, on both reconstructions all the fish localities are thought to have been in the warm (« intertropical ») zone of that time, and not far from the shore lines. If *Sacabambaspis* is really more related to the North American taxa than to the Australian ones, this once more leads to the problem of dispersal routes in the Ordovician seas. If *Sacabambaspis*, as other lower vertebrates, was probably incapable of transoceanic migrations, a more compact reconstruction is preferred (fig. 2B). Possible tests of our hypothesis could be finding new specimens in Bolivia and between Bolivia and North America.

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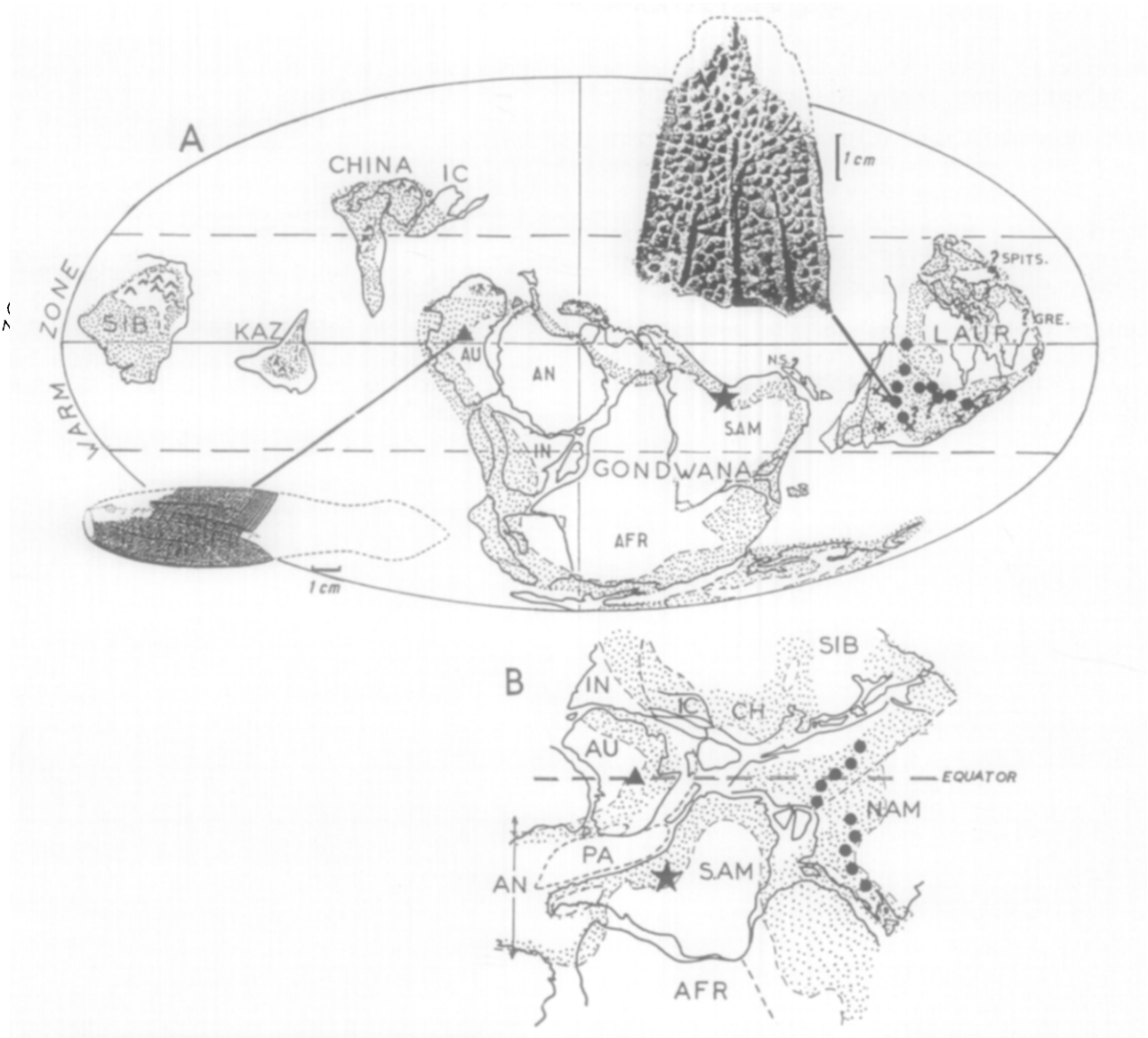

Fig. 2 — **Palaeogeographic reconstructions for the Ordovician** (Llandeilo-Caradoc) with location of the Lower, Middle, and Upper Ordovician vertebrate records.

A - palaeogeography after Scotese & *alii* (1979), with « deep sea » unshaded, shallow seas stippled, lands grey-coloured, slightly modified after Turner (1978). Black triangle locates the *Arandaspis* [reconstruction in left lateral view : Ritchie & Gilbert-Tomlinson 1977], and *Porophoraspis* assemblage from Australia. Black circles locate the *Astraspis*, [with a dorsal view of the partly articulated dorsal shield : Stensiö 1964], and *Eriptychius* assemblage from North America. The black star locates the new genus *Sacabambaspis*.

B- palaeogeography after Shields 1979 in the hypothesis of a Pangeric reconstruction through Palaeozoic times, but on a smaller Earth. The double dashed line approximates the location of the Ordovician equator (Spjeldnaes 1979).

Abbreviations : AFR-Africa, AN-Antarctica, AU-Australia, CH-China, GRE-Greenland, IC-Indochina, IN-India, KAZ-Kazakhstan, LAU-Laurentia, N.AM-North America, NS-Nova Scotia, PA-Pacifica, S.AM-South America, SIB-Siberia, SPITS-Spitsbergen.

Reconstitutions paléogéographiques à l'Ordovicien (Llandeilo-Caradoc) avec la localisation des Vertébrés connus à l'Ordovicien inférieur, moyen, et supérieur.

A - paléogéographie d'après Scotese & *alii* (1979), mers peu profondes en pointillé ; légèrement modifié d'après Turner (1978). Le triangle noir localise l'assemblage à *Aramdaspis*, [reconstitution en vue latérale gauche : Ritchie & Gilbert-Tomlinson, 1977] et *Porophoraspis* d'Australie. Les cercles noirs localisent l'assemblage à *Astraspis*, [vue dorsale du bouclier dorsal : Stensiö 1964] et *Eriptychius* d'Amérique du Nord. L'étoile noire localise le nouveau genre *Sacabambaspis*.

B - paléogéographie d'après Shields (1979) dans l'hypothèse d'une Pangée pérenne à travers les temps paléozoïques, mais sur une Terre de diamètre réduit. Le double tireté donne une approximation de l'équateur à l'Ordovicien (Spjeldnaes 1979).

Abréviations : AFR-Afrique, AN-Antarctique, AU-Australie, CH-Chine, GRE-Groënland, IC-Indochine, IN-Inde, KAZ-Kazakhstan, LAU-Laurentia, N.AM-Amérique du Nord, NS-Nouvelle Ecosse, PA-Pacifica, S.AM-Amérique du Sud, SIB-Sibérie, SPITS-Spitsberg.

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Manuscrit définitif reçu le 05.09.1986