

# Conodont Biostratigraphy and Paleoenvironments of the Cardonal Formation (Cambrian-Ordovician) from the Cajas Range, Cordillera Oriental, Northwestern Argentina and Paleobiogeographic Interpretation

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Important stratigraphic successions occur in Argentina that yield key new conodont biostratigraphic and paleobiogeographic data with reference to the Cambrian-Ordovician boundary interval and the Iapetus Ocean. High resolution conodont biostratigraphy, paleoenvironmental analyses and paleothermometry studies have been completed on the Cardonal Formation from the Cajas Range in the Cordillera Oriental, Jujuy Province, northwestern Argentina. The Cardonal Formation exposed in the Amarilla Creek is 160.4 m thick and paraconformably overlies the Lampazar Formation, and is tectonically overlain by the Acoite Formation. It consists mostly of sandstone, calcarenite and interbedded coquinas in its lower part with progressively higher proportions of shale in the upper section. The lower part of this siliciclastic unit was deposited in shallow subtidal to deep subtidal settings while the upper section developed in upper offshore environments.

About 60 kg of calcarenites and calcareous coquinas sampled from 32 levels in the formation were processed through conventional acid etching techniques (10% acetic acid). The productive conodont samples yielded 2631 specimens, which are assigned to the following species: *Acanthodus lineatus*, *A. uncinatus*, *Cordylodus angulatus*, *C. caseyi*, *C. deflexus*, *C. hastatus*, *C. intermedius*, *C. lindstromi*, *C. proavus*, *C. prolindstromi*, *C. cf. viruanus*, *C. cf. andresi*, *Cordylodus* n. sp., *Cordylodus* sp., *Eoconodontus notchpeakensis*, *Furnishina furnishi*, *Fryxellodontus* sp., *Iapetognathus aengensis*, *I. fluctivagus*, *Iapetognathus* n. sp., *Orminskia* n. sp., *Phakelodus elongatus*, *P. tenuis*, *Problematoconites perforatus*, *Proconodontus muelleri*, *Teridontus gallicus*, *T. nakamurai*, and *T. obesus*. From the stratigraphic distribution of the 28 identified conodont species, the following conodont zones were recognised: *Cordylodus lindstromi*, *Iapetognathus* and *Cordylodus angulatus* zones. The record of *Iapetognathus fluctivagus* Nicoll *et al.* demonstrates the presence of the *Iapetognathus* Zone for the first time in South America, which determines the base of the Ordovician System as it was established by the IUGS with a GSSP at Green Point in western Newfoundland. The intersystemic boundary is placed 101 m above the base of the Cardonal Formation at the first appearance datum of *I. fluctivagus*. The record of graptolites and trilobites such as *Rhabdinopora* and *Jujuyaspis* close to the boundary enhances this section as a standard reference for the earliest Ordovician in South America. The age of the Cardonal Formation is shown by this study to be Late Cambrian to Early Ordovician (*i.e.*, late Furongian – early Tremadocian).

Considering the relative abundance of conodont species recovered throughout the Cardonal Formation and their known ecological distribution elsewhere, statistical analysis of the fauna demonstrates a progressive deepening of the environments from inner to outer epicontinental platform settings. A mixed conodont fauna and a significant percentage of endemic species suggest mid latitudes for the paleobiogeographic unit, corresponding to the conodont Transitional Faunal Realm or to the South Gondwana Province of the Cold Water Domain in the Shallow Water Realm. The presence of certain cosmopolitan conodont taxa together with typical forms from Baltica, Laurentia and western Newfoundland verify a perigondwanan exchange of conodont species as well as migration of conodont faunas across the Iapetus Ocean.

Conodont elements of the Cardonal Formation exhibit a black color alteration (CAI 5), reflecting paleotemperatures between 300-480 °C that can be attributed to tectostratigraphic overburden and to the possible subsequent influence of the closely located Aguilar granite, which intruded the Cambrian-Ordovician succession during the Jurassic-Cretaceous boundary interval.