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MOLLUSKS OF THE TUBUL FORMATION (SOUTH-CENTRAL CHILE): IMPLICATIONS FOR THE EARLY PLEISTOCENE CLIMATE OF THE SOUTHEASTERN PACIFIC

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GEOLOGY AND FAUNA

The Tubul Formation (Figure 1) has been first described by Feruglio (1949), its type area being located on the southern side of the Gulf of Arauco (37°14' S; 73°26' W). On-shore outcrops are limited to the east by the Cordillera de Nahuelbuta and to the west by the Pacific Ocean.

According to Pineda (1986), deposition of the sediments of the Tubul Formation was rapid, in a quiet zone close to the coast, and maybe lagoonal. These sediments should correspond to the Plio-/Pleistocene-boundary (Pineda, 1986) and occur at the following localities: Punta Pichicui, Estero Chupalla, Villa Alegre, Los Alamos, Quebrada Raquilco, El Tique, Estero Licauquen, and Minas Trihueco. According to her, the Tubul Formation represents a transgressive sequence. The presence of quartz-sand and a conglomerate at the base of the formation has been interpreted as a former coastal line. Above this level, very fine clayey sandstones have been deposited, which should represent a shallow-marine environment. However, it is not the aim of this study to clarify the geological situation and age of the Tubul Formation and we therefore use this name in its broad and classical sense. The investigated mollusk fauna comes from the coastal bluffs near Las Peñas (Figure 1), which represent the uppermost part of the Tubul Formation, and includes the following species:

Ennucula grayi (d´Orbigny, 1846); *Tindariopsis sulculata* (Gould, 1852); *Malletia chilensis* Moulins, 1832; *Mytilus* sp.; *Zygochlamys patagonica* (King & Broderip, 1832); *Cyclocardia velutinus* (E.A. Smith, 1881); *Macoma inornata* (Hanley, 1844); *Darina solenoides* (King & Broderip, 1832); *Ensis macha* (Molina, 1782); *Retrotapes exalbidus* (Dillwyn, 1817); *Pandora cistula* Gould, 1850; *Epitonium* (*Nitidiscala*) *magellanicus* (Philippi, 1845); *Polinices* sp.;

Fusitriton magellanicus (Röding, 1798); *Sassia leucostomoides* (Sowerby, 1846); *Trophon geversianus* (Pallas, 1774); "*Xymenopsis*" cf. "*X.*" *dispar* Rochebrune & Mabille, 1889); *Chorus giganteus* (Lesson, 1829); *Nassarius taeniolatus* (Philippi, 1845); *Adelomelon ancilla* (Ligthfoot, 1786); *Bela paesleri* Strebel, 1905; *Scaphander interruptus* Dall, 1889; *Dentalium* sp.

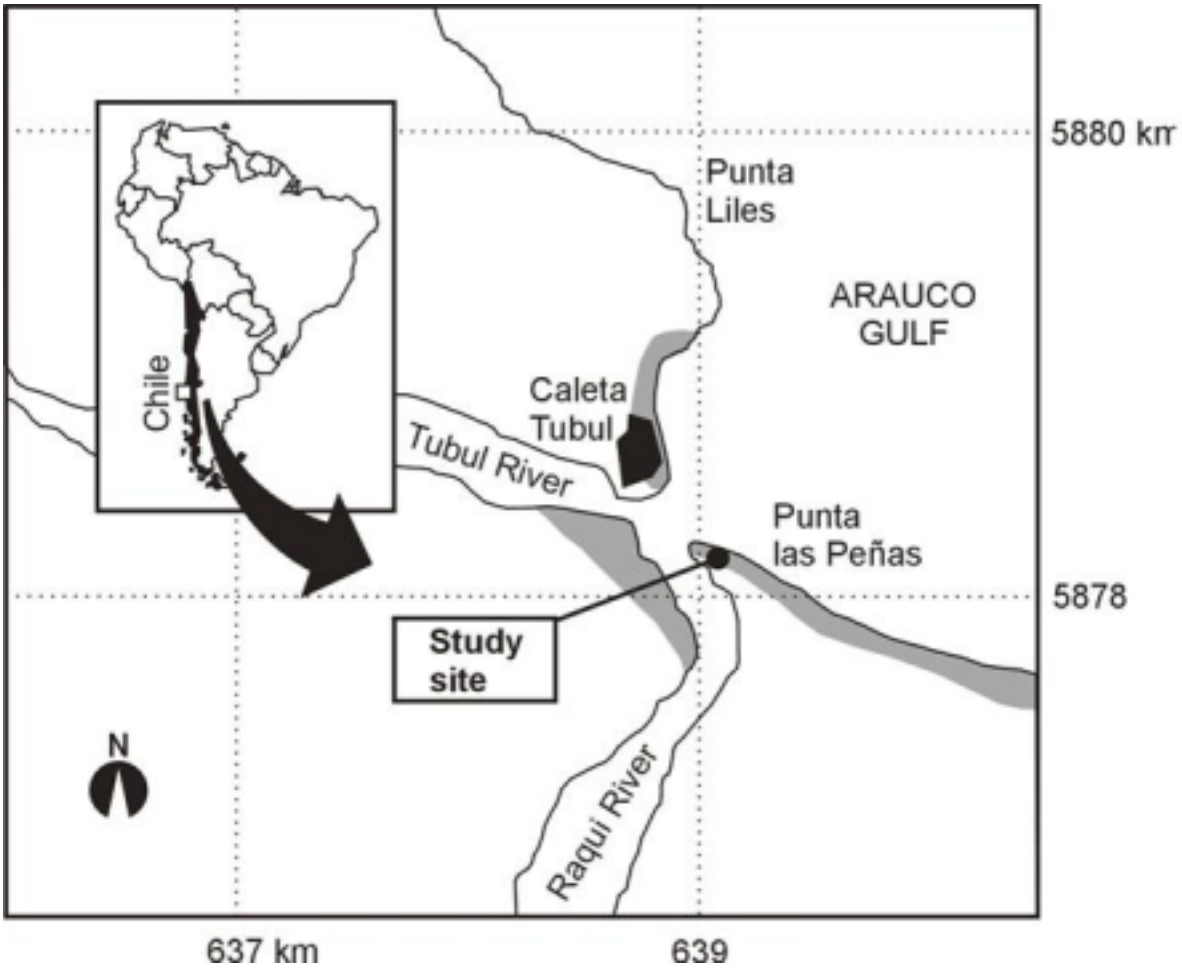

Figure 1. Area of the Tubul Formation (Chile) and sample site.

COMPARISON WITH OTHER FAUNAS AND CONCLUSIONS

Subjacent of the Tubul Formation is the late Miocene to early Pliocene Ranquil Formation (Pineda, 1986; Finger et al., submitted), the fauna of which is similar to that of the Navidad Formation south of Valparaíso (see Philippi, 1887; Nielsen, 2004; Nielsen et al., 2004). This fauna has been

reworked and is of early to middle Miocene age (DeVries and Frassinetti, 2003; Finger et al., submitted; Nielsen & Glodny, 2006) and contains many subtropical gastropod genera like *Nerita*, *Strombus*, *Xenophora*, *Distorsio*, *Echinophoria*, *Ficus*, *Terebra* and *Architectonica* (see Nielsen & Glodny, 2006) which disappeared during the late Miocene climate cooling. A number of the gastropod genera described herein (*Epitonium*, *Natica*, *Trophon*, *Chorus*, *Nassarius*) were already present in Chile during the Miocene, but were represented by different species. If and how these are related to the living taxa has yet to be investigated.

The Plio-Pleistocene faunas from northern Chile have a different composition to that of the Tubul Formation, containing abundant Trochoidea, *Fissurella*, *Turritella*, *Crucibulum*, *Trochita*, *Crepidula*, different species of Naticidae (including *Sinum cymba*), *Argobuccinum*, *Nassarius*, *Acanthina*, *Chorus* and *Oliva peruviana* (Herm, 1969; DeVries, 1997, 2003; own data), representing today's coastal fauna of northern to central Chile. However, these are near-coast faunas with many taxa from rocky coasts, while that of Tubul is a soft-bottom fauna from slightly deeper water, missing typical rocky-shore elements like *Fissurella*, *Acanthina* and *Concholepas*, which are present in the Plio-Pleistocene deposits of northern Chile and in the modern fauna along the whole Chilean coast.

The first appeareance of *Chorus giganteus* in southern Peru during the latest Pliocene makes this a likely maximum age for the Tubul fauna. Indeed, this agrees well with strontium isotope data from specimens of *Zygochlamys patagonica*, which confirm an early Pleistocene age (own unpublished data). The fauna of the Tubul Formation resembles the present-day fauna of the Magellan Region while northern faunas of the Pliocene to Pleistocene have a composition similar to that of modern northern and central Chile. Water temperatures are accordingly interpreted to have been colder than today.

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