

## First record of Cambrian pelagiellids from Sardinia

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with 4 figures and 1 plate

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### Abstract

From the upper Lower to Middle Cambrian Campo Pisano Formation of southwestern Sardinia, pelagiellid molluscs are described for the first time. The specimens are identified as *Pelagiella subangulata* (TATE, 1892); their systematic affiliation is shortly discussed. The biostratigraphic position of this new findings is lowest Middle Cambrian. Palaeoecologically, the Sardinian material (such as the specimens of the German Cambrian) indicates the transition from shallow to mid-subtidal open-marine conditions.

### Zusammenfassung

Aus Karbonaten der hoch-unter- bis mittelkambrischen Campo Pisano Formation SW-Sardiniens werden erste Funde pelagiellider Mollusken gemeldet. Die als *Pelagiella subangulata* (TATE, 1892) identifizierten Formen werden hinsichtlich ihrer systematischen Stellung kurz diskutiert und biostratigraphisch in das unterste Mittelkambrium gestuft. Paläoökologisch spiegeln die sardischen Formen (ebenso wie die des deutschen Kambriums) den Übergang vom flachen zum mittleren Subtidal offenmariner Verhältnisse wider.

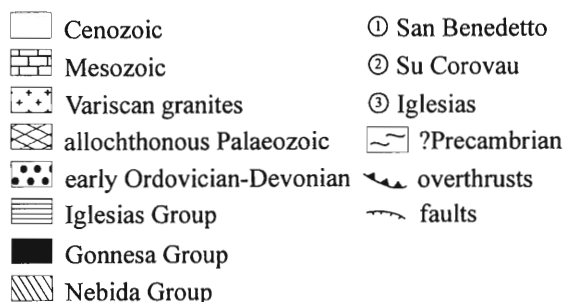
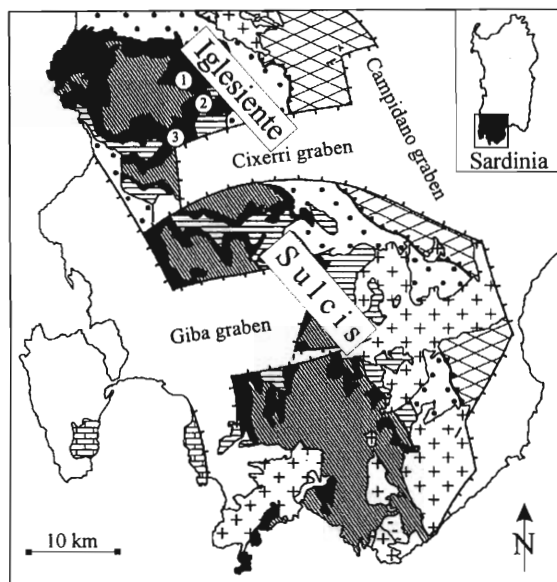
### 1 Introduction

In southwestern Sardinia an autochthonous succession of early Palaeozoic sediments is widely exposed (fig. 1). The area belongs to the classic European mining regions and so, sedimentary and stratigraphic questions arrived early into the centre of interest. Regarding the Cambrian, after first research activities in the second half of the 19<sup>th</sup> century, a more intensive work was carried out during the last decades. The main work was realized by DEBRENNE, COCOZZA, GANDIN, BECHSTÄDT, BONI, PILLOLA and their research groups (for more detailed research history, see PILLOLA, 1991 and BECHSTÄDT & BONI, 1994).

The autochthonous Palaeozoic of southwestern Sardinia is geologically bordered to the East by a large trap unit (fig. 1). Morphologically, the Tertiary Campidano graben separates the region from the other parts of the island.

The Cambrian of the area (fig. 2) consists of a 1500-2500 m thick sedimentary succession (PILLOLA, 1991) which documents the geological evolution from a siliciclastic shelf and a mixed siliciclastic-carbonate ramp (Nebida Group), to an isolated carbonate platform (Gonnesa Group) and subsequently to a drowning carbonate platform (early Iglesias Group: Campo Pisano Fm.), (BECHSTÄDT et al., 1985 and 1988; BECHSTÄDT & BONI, 1994). The deposition of the overlying siliciclastic part of the Iglesias Group (Cabitza Fm.) proceeds continuously into the Ordovician. Whereas the lower boundary of the Cambro-Ordovician succession is not clear because of problematic outcrop conditions, the upper boundary, in contrast, is marked by a distinct erosive contact caused by Tremadocian/Caradocian tectonic movements (Sardic phase).

Palaeogeographically, it is commonly accepted that southwestern Sardinia was part of the western Gondwana margin, a region which was located in more or less subequatorial position during early Cambrian times (e.g. McKERROW et al., 1992; COURJAULT-RADÉ et al., 1992; DEBRENNE & COURJAULT-RADÉ, 1994; TORSVIK et al., 1996; SESLAVINSKY & MAIDANSKAYA, 2001). The Sardinian Cambrian succession is typical Mediterranean in its general lithological and in its faunal characteristics and well comparable with simultaneous evolutions of other acado-baltic regions (SDZUY, 1972; PILLOLA, 1991).



The Campo Pisano Fm. of the Iglesias Group – containing the fauna discussed here – has received relatively little detailed study in the past. Sporadic investigations were rather subordinate aspects of work on other Cambrian levels and focused on some fossil finds, on the general occurrence of carbonate types, and on depositional conditions (RASETTI, 1972; COCOZZA, 1979; GANDIN, 1979; CHERCHI & SCHROEDER, 1984; MOSTLER, 1985; SCHLEDDING, 1985; BECHSTÄDT & BONI, 1989; COCOZZA & GANDIN, 1990; PILLOLA, 1991; ELICKI, 2001). Since some time more intensive facies and palaeontological investigations of the Campo Pisano Fm. are in progress at the Freiberg University. This work is focused on the microfauna. The aim of the given paper is to announce the first observation of a special mollusc group - pelagiellids - from the Cambrian of Sardinia.

The working area in southwestern Sardinia is located north and northeast of the provincial capital Iglesias (compare fig. 1). The San Benedetto section (“Gutturu Canali Acquis” locality by BECHSTÄDT & BONI, 1994) is near the same called village, about one kilometre to the East, at the northern slope of “hight 692” of the Punta Corremo hill. The second working section (Su Corovau) is located 3.5 kilometre northwest of Domusnovas village (about two kilometres northwest of passage through the famous karst-cave “Grotta San Giovanni”).

Fig. 1: Geological map of southwestern Sardinia (modified after BECHSTÄDT et al., 1988).

## 2 Geological Setting

The Iglesias Group is subdivided into two members: The lower one is the Campo Pisano Fm. which represents the drowning stage of the carbonate platform. Limestones and sometimes dolomites and a higher content of siliciclastics (in comparison to the underlying Gonnesa Group) as well as the often observable nodular texture of the carbonates are characteristic. The upper part of the Iglesias Group is represented by the Cabitza Fm. which consists of silt- and sandstones covering the drowned platform.

The carbonates of the Campo Pisano Fm. (mostly wackestones, subordinately mudstones, packstones and floatstones) contain a rich, but, hardly accessible shelly fauna. So, only few material was hitherto extracted successfully for taxonomic investigation. From different outcrops of the Iglesias area some authors have

described trilobites, sponge spicules and single findings of foraminifera, calcimicrobes and a phosphatic microproblematicum (*Hadimopanella*). Furthermore, the occurrence of echinoderm plates, brachiopods, cancelloriids, hyoliths and recently also of bradoriids and cambroclaves has been mentioned (GANDIN, 1979; CHERCHI & SCHRÖDER, 1984; MOSTLER, 1985; PILLOLA, 1986 & 1991; LOI et al., 1995; ELICKI, 2001; ELICKI & WOTTE, in press). From the overlaying Cabitza Fm. trilobites, echinoderms, brachiopods, hyoliths and trace fossils are known (compare LOI et al., 1995). Based on the trilobites a stratigraphic decision was given by PILLOLA (in LOI et al., 1995): so, the Campo Pisano Fm. occupies a time span from the latest Bilbilian until lower Caesarugustan. The Cabitza Fm. reaches from the lower Caesarugustan until Tremadocian (and can be further subdivided biostratigraphically).

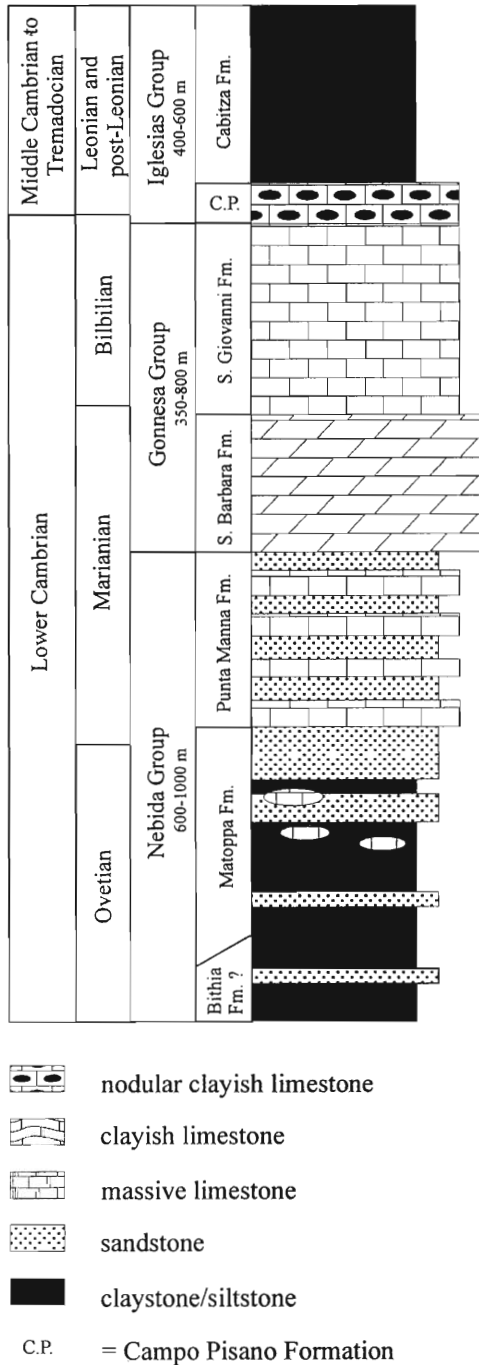


Fig. 2: Geologic - stratigraphical column of the Cambrian of southwestern Sardinia (modified after BECHSTÄDT & BONI, 1994)

The sedimentary environment during deposition of the Campo Pisano Fm. as well as the morphology of the area and the bathymetric conditions are still under discussion. The most popular model for the deposition of the Campo Pisano Fm. is a drowning platform affected by extensional tectonics accompanied by a rising sea level and maybe by climate cooling. The tectonics led to a breakup of the platform into blocs with different subsidence rates. On morphological higher situated blocs the nodular limestones should have originated; whereas within the lower situated troughs in between lithotypes with a higher content of siliciclastics were deposited (e.g. GANDIN, 1979; SCHLEDDING, 1985; BECHSTÄDT et al., 1988; COCOZZA & GANDIN, 1990; LOI et al., 1995). Based on the investigation of the microfacies and on fossil assemblages ELICKI (2001) concluded a rather uniform and geomorphologically low differentiated, subtidal (neritic) environment affected by significant subsidence impulses at the beginning and at the end of the Campo Pisano Fm.

As well the San Benedetto section as the Su Corovau section start with fossil assemblages very rich in sponge spicules (a feature which is often to observe also in other Sardinian sections, e.g. compare ELICKI, 2001). But, after some decimetres the sponges degree and a high amount of trilobites, echinoderm plates and shelly remains (which are sometimes accompanied by some cancelloriids, hyoliths and problematic fossils) occur and persist more or less until the end of the Campo Pisano Fm.

The pelagiellid remains - interesting here - occur relatively early in the successions: within the interval between 10 m and 15 m (San Benedetto) and between 2 m and 4 m (Su Corovau) above the basis of the Campo Pisano Fm. The occurrence, interestingly, seems to be limited to this small interval which indicates an opening and deepening of the environment (ELICKI, 2001) - a phenomenon which can also be observed in the German pelagiellid bearing section (ELICKI, 1994).

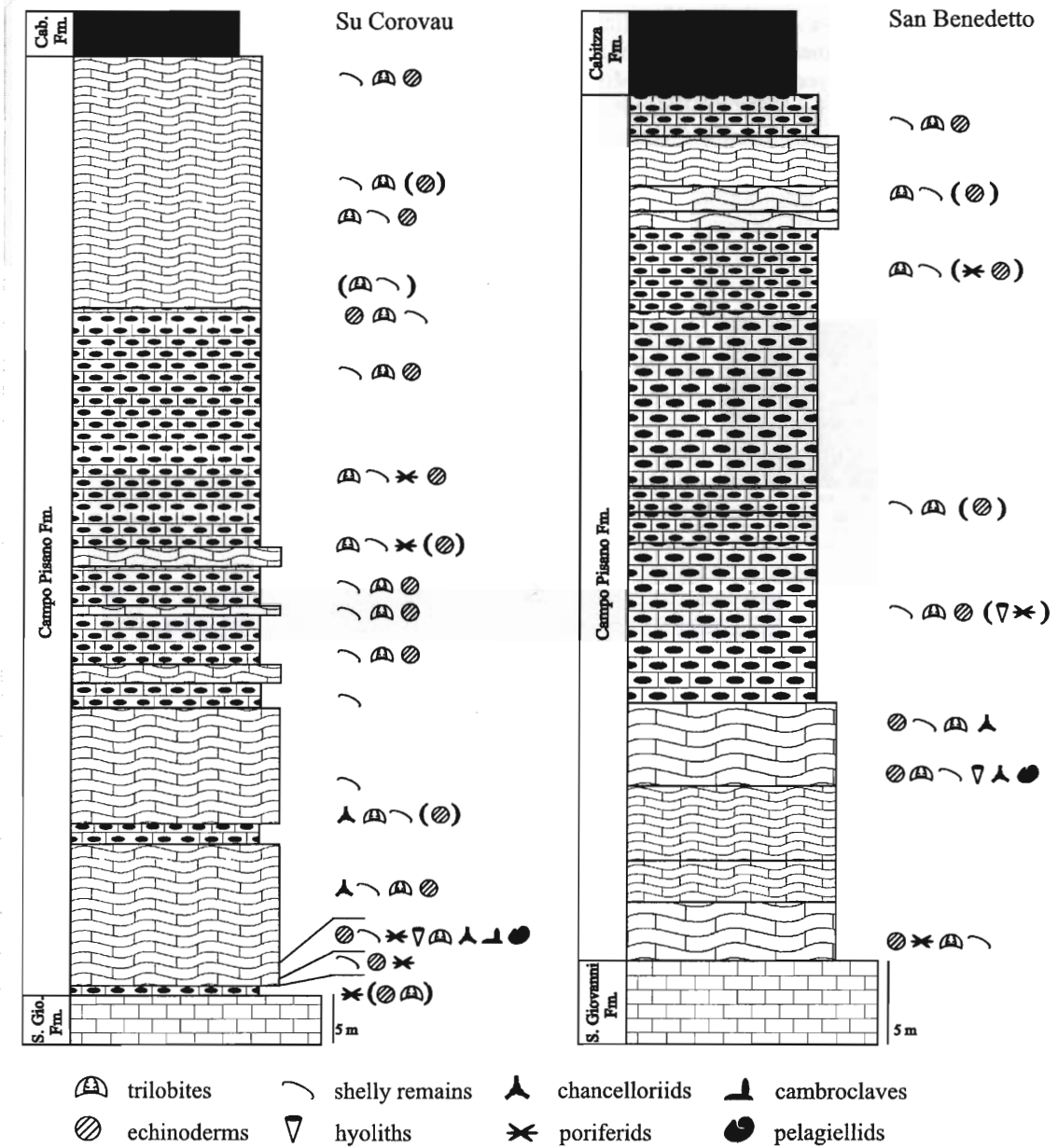


Fig. 3: Geological columns and fossil content of the pelagiellid-bearing sections “Su Corovau” and “San Benedetto” in the Iglesiente region (for lithology see fig. 2).

### 3 Systematic palaeontology

The systematic position of pelagiellids is under debate. So, RUNNEGAR (1981) saw an affiliation to the monoplacophorans because of his reconstruction of the soft body (later on, GUBANOV & PEEL [2000] classified all Cambrian monoplacophoran molluscs into the class Helcionellida). GEYER (1986), in contrast, mistrust such a conclusion due to the shape of the primary shell and the absence of the muscle imprints typical for this group. Another point of view, also based on the primary shell, was published by PARKHAEV (in ALEXANDER et al., 2001), who relocated pelagiellids as a family of the Pelagielliformes - an order of his new erected subclass Archaeobranchia. Whereas the first two authors decline an affiliation of pelagiellids to the class Gastropoda CUVIER (1797), PARKHAEV (in ALEXANDER et al., 2001) and also LANDING et al. (2002) - reviewing the arguments on hard parts, soft parts and functionality - conclude that pelagiellids represent real gastropods of the order Pelagielliformes (interpretation of PARKHAEV) or Archaeogastropoda (interpretation of LANDING et al.),

respectively. RUNNEGAR & POJETA (1985), in contrast, combined pelagiellids within an own order named Pelagiellida. Despite the still open discussion, in this paper for the systematic position of pelagiellids the author follows the interpretation in the sense of LANDING et al. (2002).

Because of many new findings during the last decades more than thirty species of the genus *Pelagiella* are known. The quality of their preservation and description is very different. So, without a restudy of all the holotype material the species content remains confusing and an only partially re-organisation of the specimens classification should be avoided.

Class Gastropoda CUVIER, 1797  
Subclass Prosobranchia MILNE EDWARDS, 1848  
Order Archaeogastropoda THIELE, 1925  
Superfamily Pelagielloidea KNIGHT, 1956  
Family Pelagiellidae KNIGHT, 1956  
Genus *Pelagiella* METTHEW, 1895

Type species: *Cyrtolites atlantoides* METTHEW, 1895

*Pelagiella subangulata* (TATE, 1892)  
(Tafel I/1-18)

*Ophileta subangulata* TATE, 1892

*Pelagiella emeishanensis* HE in XING et al., 1984: 167, pl. 13/1-5

*Pelagiella emeishanensis* HE in XING et al., 1984; Ellicki, 1996: 155, pl. 7/6-7

**Material:** 1 specimen from San Benedetto (sample ca2), 31 specimens from Su Corovau (sample sc4: 17 specimens; sample sc5: 14 specimens). All samples represent bioclastic wackestone to packstone. The accompanying fauna consists of dominating echinoderm-plates and trilobite carapaces, and yields further unidentified shelly remains and minor amounts of hyoliths. Sample sc4 also contains some phosphatic microproblematica (cambroclaves: ELICKI & WOTTE, in press). Preservation of the material: steinkerns, mostly poorly preserved and sometimes a little deformed; relics of shell pseudomorphs are very rare.

**Description:** Small dextral coiled, turbospiral steinkerns; number of whorls: about 1.5; umbilicus narrow, last whorl wide. Protoconch often slightly hooked. The simple organized aperture is nearly oval, slightly tilted and opens conspicuously after about two third of the coil. The upper margin is distinctly convex, the lower one flat. The steinkern's surface is smooth. There are no signs of ribs or other distinct shell features. Some steinkerns show a microbial colonialization by endolithic cyanobacteria (*Endoconchia* RUNNEGAR, 1990a).

**Remarks:** The Sardinian specimens are very similar to *P. emeishanensis* HE in XING et al., 1984 and *P. aff. adunca* (HE & PEI in HE et al., 1984) published from the Early Cambrian of Germany (ELICKI, 1994 & 1996). But, the morphological variation of *Pelagiella* METTHEW, 1895, is rather large. For *P. subangulata* (TATE, 1892) it seems, that there are transitional morphs which lead over continuously to *P. adunca* (HE & PEI in HE et al., 1984). Following the arguments of PARKHAEV (in ALEXANDER et al., 2001), the last is an invalid name of *P. madianensis* (ZHOU & XIAO, 1984). So, it may be that *P. subangulata* (TATE, 1892) and *P. madianensis* (ZHOU & XIAO, 1984) represent morphological variations (different ends of a continuous shape line) of the same species (see also RUNNEGAR, 1990b). After PARKHAEV's arguments a sure distinction between both forms needs adult specimens with a good (shell-) preservation. Nevertheless, he re-decided surprisingly a lot of (partly bad preserved) steinkerns of other authors to *P. subangulata* (TATE, 1892). On the other hand, *P. emeishanensis* HE in XING et al., 1984 - following PARKHAEV - is a synonym of *P. subangulata* (TATE, 1892). By these reasons and in consideration of the unresolved taxonomic problems the specimens presented here are placed into the accumulative species *P. subangulata* (TATE, 1892).

*P. subangulata* (TATE, 1892) is known from the higher Lower to Middle Cambrian of Australia (South Australia and Northern Territory), from the Botoman of Germany and from the Qiongzhusi of China (Sichuan). The genus is a common element of shallow marine faunal assemblages of this time interval.

The biostratigraphic position of the Sardinian pelagiellids can be constrained by correlation to the Campo Pisano type section near Iglesias. From there *Protolenus* cf. *pisidianus* is described from the lower part of the section (PILLOLA, 1991; LOI et al., 1995). Where *Paradoxides* is missing, this occurrence is indicative of the Early/Middle Cambrian boundary in the Mediterranean (PILLOLA in LOI et al., 1995). But, no *Protolenus* has

been found so far neither in the San Benedetto nor in the Su Corovau section. A stratigraphic definition of the pelagiellid-bearing layers, however, is possible because of the typical succession of facies types at the beginning of the Campo Pisano Formation (ELICKI, 2001). Normally, the Campo Pisano Formation starts with a spiculite facies which turns into an echinoderm-rich facies after only some decimetres. Within the Campo Pisano type section immediately above the *Protolenus cf. pisidianus* layer this first echinoderm-rich facies starts. So, the transition from spiculite facies to echinoderm facies seems to correspond (as an ecostratigraphic boundary) in the working area with the biostratigraphic Early/Middle Cambrian boundary. Consequently, the base of the horizons containing the pelagiellids (which represents the first echinoderm-rich layer in the Su Corovau and the San Benedetto sections) can be roughly correlated with the Early/Middle Cambrian boundary. Therefore, the stratigraphic position of the Sardinian pelagiellids is lowest Middle Cambrian.

## Acknowledgements

For very welcome help during field work I thank GIAN LUIGI PILLOLA (Cagliari) and MARIA BONI (Naples). Further thanks go to KATJA HESSE and ANKE HÖFER (Freiberg University) which helped with micro-palaeontological preparations as well as to ANJA OBST (Freiberg) for SEM photography. The investigations were supported the German Research Foundation (DFG), project EL 144/5: "Facies and paleology of the final stage of a Cambrian platform evolution – the small shelly fauna of the Campo Pisano Fm./SW-Sardinia".

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## Plate I

*Pelagiella subangulata* (TATE, 1892) from the early Middle Cambrian of the Iglesias region/Sardinia.  
Archive number: FG 410.  
Each scale bar is 200  $\mu\text{m}$ .

- Fig. 1-4 Steinkern specimen from the San Benedetto section; sample ca2; (1-2) SEM photographs; (3-4) light microscope photographs of the same specimen.
- Fig. 5-7 Steinkern specimen from the Su Corovau section; sample sc4; (5-6) SEM photographs; (7) light microscope photograph of the same specimen.
- Fig. 8 Steinkern specimen from the Su Corovau section; sample sc4; SEM photograph.
- Fig. 9-10 Steinkern specimen from the Su Corovau section; sample sc4; (9) SEM photograph; (10) light microscope photograph of the same specimen.
- Fig. 11-13 Steinkern specimen from the Su Corovau section; sample sc5; (11-12) SEM photographs; (13) light microscope photograph of the same specimen.
- Fig. 14-16 Steinkern specimen from the Su Corovau section; sample sc5; (14-15) SEM photographs; (16) light microscope photograph of the same specimen.
- Fig. 17-18 Steinkern specimen from the Su Corovau section; sample sc5; SEM photographs.

