**Zeitschrift:** Eclogae Geologicae Helvetiae
**Herausgeber:** Schweizerische Geologische Gesellschaft
**Band:** 57 (1964)
**Heft:** 1

**Artikel:** Fossil remains in Staurolite-Kyanite Schists of the Bedretto-Mulde Bündnerschiefer

**Autor:** Higgins, Anthony K.

**DOI:** https://doi.org/10.5169/seals-163139

# Fossil Remains in Staurolite-Kyanite Schists of the Bedretto-Mulde Bündnerschiefer

By **Anthony K. Higgins** (Imperial College, London)

With 4 figures in the text

## INTRODUCTION

The Lower Pennine nappes outcrop in the Simplon-Ticino area, a highly metamorphosed and structurally complex region (WENK, 1962; CHATTERJEE, 1961). In the course of a detailed investigation of the structural and metamorphic history of a part of the Ticino area situated to the west of Airolo an assemblage of well-preserved fossils was discovered in the highly metamorphosed Bedretto-Mulde Bündnerschiefer. The preservation of this material is remarkable on two counts: first the schists contain staurolite, garnet and kyanite porphyroblasts, and second the rocks have been strongly deformed by several phases of Alpine movements. The main results of these structural and metamorphic studies are to be presented elsewhere, the aim of this paper is to discuss the preservation and significance of the fossil material.

## THE FOSSIL LOCALITIES

The Mesozoic schists in which the fossils were found are situated 14 kilometres south-west of Airolo to the south of the St. Gotthard pass. The area of the discoveries lies within the extension eastwards of the staurolite-kyanite sub-facies established by CHATTERJEE (1961) in the Simplon area. The Simplon-Ticino region was further divided by WENK (1962) into metamorphic zones each characterised by plagioclase of a certain range of composition. Plagioclases of anothite content between 30% and 50% characterise the zone including the fossiliferous strata.

In the vicinity of the discoveries only the metamorphosed parautochthonous Lias from the cover of the Gotthard massif has furnished fossils. In this zone a varied fauna of belemmites, ammonites, lamellibranchs and a few foraminifera have been recorded (LARDY 1832; STELLA 1904; SCHMIDT & PREISWERK 1908; SALOMON 1911; EICHENBERGER 1924; MEIER & NABHOLZ 1949).

The only fossil recorded in the Bündnerschiefer of the Pennine nappe zones is a Triassic crinoid described by SCHMIDT (1907, p. 505) from the Monte Carnera syncline of the Simplon area. Less metamorphosed Bündnerschiefer have yielded radiolaria, small mollusca, bryozoan, crinoid and echinoid fragments (NABHOLZ 1945; BOLLI & NABHOLZ 1959).

The lithological variations seen in the Pennine Bündnerschiefer within the area of the new discoveries have been described by BURCKHARDT (1942) and GÜNTHERT

(1954). Two and a half kilometres south of All'Aqua in the Val Bedretto a thick series of calcareous quartzites make up the conspicuous white summit of Pizzo di S. Giacomo. Between these quartzites and the northern boundary of the core of the Lebendun nappe BURCKHARDT has recorded the presence of a band of garnetiferous schist. This is the horizon which has yielded the fossil remains (fig. 1).

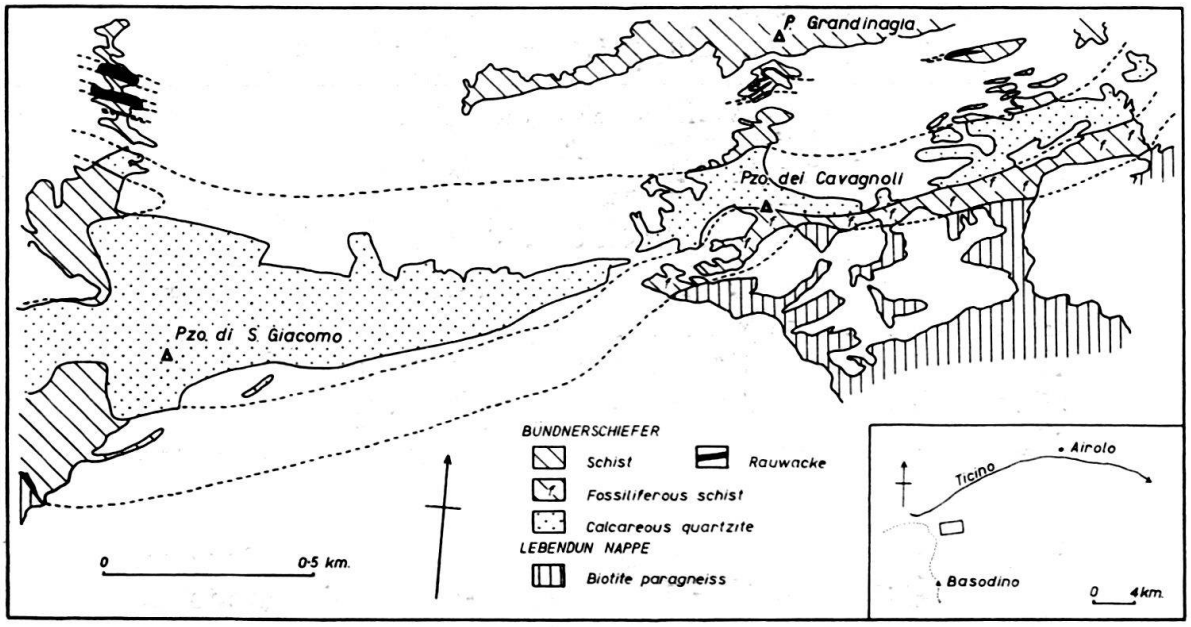


Fig. 1. Location of the fossiliferous schists.

A large number of specimens of this schist have been collected from several localities. Although no traces of the fossil debris could be seen in the hand specimens, about 25% of the specimens revealed fossil remains in thin section. The fossils are all very small (less than 1 mm in diameter), and occur among porphyroblasts of garnet, staurolite and plagioclase, set in a matrix of muscovite, biotite, quartz, rutile and abundant graphite. Kyanite porphyroblasts have been observed in thin sections of some specimens of this schist though not in those bearing the fossil remains.

## DESCRIPTION OF THE FOSSILS

All except one of the fossil fragments are of the type shown in figs. 2 and 3. In section the fragments are sometimes oval (fig. 2) or polygonal (fig. 3), but more often are completely irregular. The internal parts have a typical reticulate appearance, the structure often well preserved in an opaque material. This type of internal texture corresponds closely with cross sections of the plates, spines and other skeletal parts of echinoids and crinoids (MOORE, LALICKER & FISHER, 1952). The tests of recent echinoderms are often very porous on account of the open nature of the reticulate texture of the skeletal parts. During the process of fossilisation the interstices are commonly infilled with crystalline calcite. From examination of the fossil remains found in the Bündnerschiefer it is clear that some other process has intervened subsequent to the death of the organism.

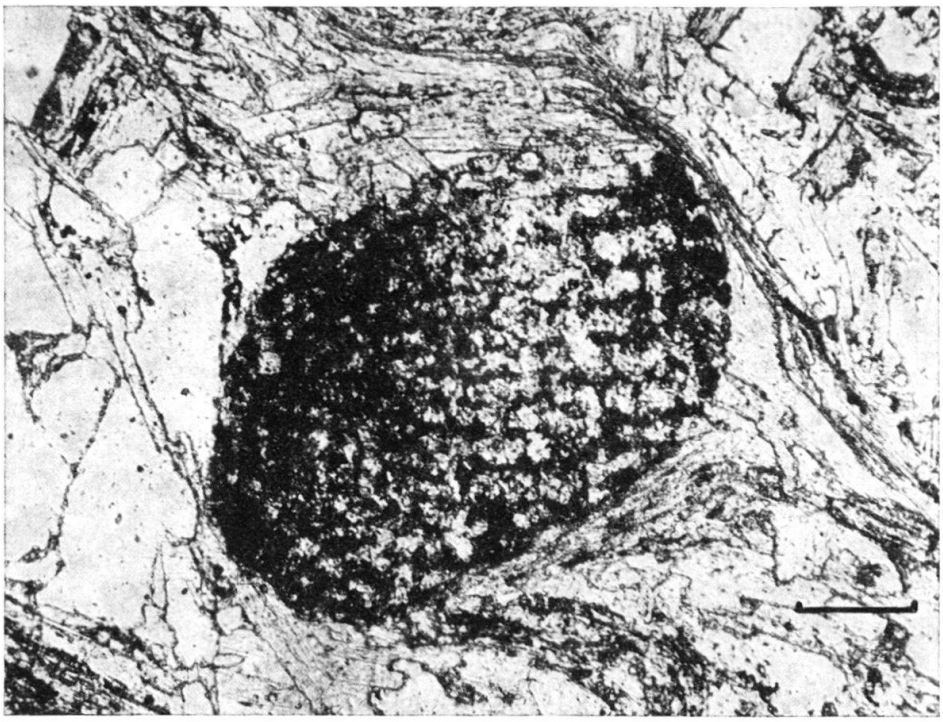

Fig. 2. Echinoderm debris (scale is 0.1 mm).

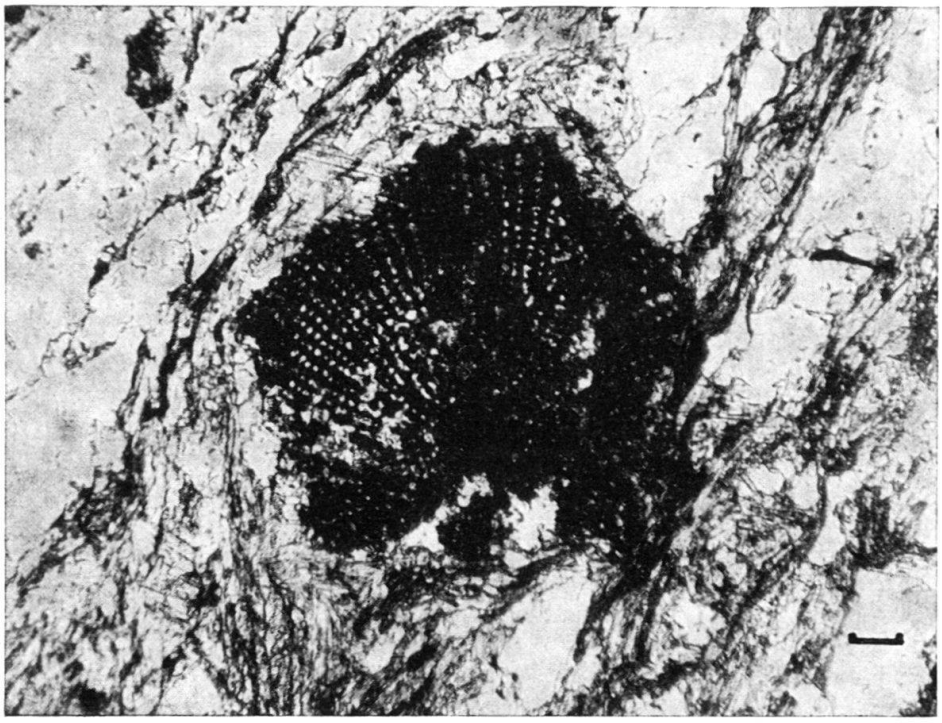

Fig. 3. Echinoderm debris (scale is 0.1 mm).

The unique fossil of fig. 4 exhibits rather different structural features to those described above although it is preserved in a similar opaque material. The fossil has an arcuate border and preserves five oral areas, that perhaps represent chambers, arranged in a radial or spiral pattern. It resembles most closely sections of foraminifera or algae.

Fig. 4. Foraminiferal or algal fragment (scale is 0.1 mm).

## MODE OF PRESERVATION

The fossils are all preserved in a similar opaque material which appears to have resisted deformation during the several Alpine movements which are recorded in these rocks. Frequently the foliation, defined by trails of graphite particles, is seen to be deflected around the fossils.

In order to investigate the nature of this opaque substance polished sections of the fossiliferous schists were prepared and studied under a reflected light microscope. Under high magnification ($\times$ 2000) with an oil immersion lens, the opaque material was resolved into myriads of minute pyrite spheres of diameter less than 1 $\mu$ arranged in clusters and scattered particles. Associated with the pyrite was a second mineral of poor reflectivity which could not be positively identified. It is neither graphite nor an ore mineral and may be organic.

Pyrite spheres of this type are characteristic of certain sediments, and are abundant in dark shales of the sapropelic environment (Deans, 1948, p. 349–350). Pyrite spheres have been described in association with micro-organisms of unknown affinity, and as infillings of foraminifera, ostracods, diatoms, plant tissue and goniatites in rocks from pre-Cambrian to Recent age (Love, 1957, 1962; Love & Zimmerman, 1961; Love & Murray, 1963). Dissolution of the pyrite has yielded clear granules or cell bodies 0.5 to 2.0 $\mu$ in diameter (Love, 1962; Love & Murray, 1963).

It is probable that the cavities of the echinoderm plates were filled by small pyrite spheres before consolidation of the sediment. The Alpine deformations and metamorphism resulted in the replacement of the calcite of the echinoid test by biotite, plagioclase and other new minerals, the pyrite spheres remaining unre-

placed. The pyrite spheres, bonded together by some cementing material, resisted both rock distortions and high metamorphism.

The cell bodies normally associated with the pyrite spheres might in some way have acted as a bonding material, but this seems unlikely. LOVE & ZIMMERMAN found that, although the cell bodies survived mild metamorphism in nature they break up on 'intense heating' in the laboratory.

The preservation process outlined above may not hold for the unique fossil of fig. 4, which appears to be a direct replacement. The exact nature of the opaque material could not be determined without destroying the fossil, but it appears to be mainly pyrite.

Echinoderm remains have been recorded in metamorphic rocks from several areas in the Alps, although rarely from areas of comparable structural complexity or such a high grade of metamorphism. STAPFF (1892) recorded and figured crinoidal debris in marbles from the St. Gotthard tunnel, and KRIGE (1918) described similar material from Val Piora. The well known schists from the Scopi region have yielded abundant but local crinoid fragments (SCHMIDT, 1891; BAUMER et al., 1961). NABHOLZ (1945) has also noted echinoid and crinoid remains in the Pennine Bündnerschiefer of Piz. Terri. From these descriptions it seems that the type of fossil material and the nature of its preservation is somewhat similar to the forms described here. The preserving material is variously described as iron ore, zoisite, graphite or a «coaly» substance.

## SIGNIFICANCE OF THE DISCOVERIES

The fossils here described, while adding to the meagre fossil record of the Pennine Bündnerschiefer, do not assist in elucidation of its stratigraphic problems. Pyrite is abundant in much of the Bündnerschiefer, although euxenic bottom conditions do not appear to have been widespread (TRÜMPY, 1960).

The general scarcity of fossils in metamorphic rocks has been discussed by BUCHER (1953). BOLLI & NABHOLZ (1959) and TRUMPY (1960) consider that the lack of fossils in the Bündnerschiefer is probably due to the comparative sterility of the original environment, although metamorphism has probably led to the obliteration of the few forms that existed in the sediments. The great interest of the organic material discovered in the Pennine region is its remarkable degree of preservation even though the rocks lie within the kyanite isograd. The survival of the fossils described here is attributed to their peculiar mode of preservation.

## ACKNOWLEDGEMENTS

The author wishes to thank Dr. A. P. MILLMAN for assistance in ore microscopy techniques, Mr. J. GEE for taking the photomicrographs, and Dr. J. G. RAMSAY and Dr. D. V. AGER for constructively criticizing the manuscript. The work was undertaken during tenureship of a D.S.I.R. Research Studentship at Imperial College, which is greatfully acknowledged.

## REFERENCES

BAUMER, A., FREY, J. D., JUNG W. & UHR, A. (1961): *Die Sedimentdeckung des Gotthard-Massivs zwischen oberem Bleniotal und Lugnez.* Eclogae geol. Helv. *54*, 478–491.

BOLLI, H. M. & NABHOLZ, W. K. (1959): *Bündnerschieferähnliche fossilarme Serien und ihr Gehalt an Mikrofossilien.* Eclogae geol. Helv. *52*, 237–270.

BUCHER, W. H. (1953): *Fossils in metamorphic rocks.* Bull. geol. Soc. Amer. *64*, 275–300.

BURCKHARDT, C. E. (1942): *Geologie und Petrographie des Basodino-Gebietes.* Schweiz. min. petrogr. Mitt. *22*, 99–186.

CHATTERJEE, N. D. (1961): *The alpine metamorphism in the Simplon area, Switzerland and Italy.* Geol. Rdsch. *51*, 1–72.

DEANS, T. (1948): *The Kupferschiefer and the associated lead-zinc mineralisation in the Permian of Silesia, Germany and England.* Internat. Geol. Congress. 18th, London. Rept. pt. 7, 340–352.

EICHENBERGER (1924): *Geologische-petrographische Untersuchungen am Südwestrand des Gotthard-massivs (Nufenengebiet).* Eclogae geol. Helv. *18*/3, 451–483.

GÜNTHERT, A. (1954): *Beiträge zur Petrographie und Geologie des Maggia-Lappens.* Schweiz. min. petrogr. Mitt. *34*, 1–159.

KRIGE, L. J. (1918): *Petrographische Untersuchungen im Val Piora und Umgebung.* Eclogae geol. Helv. *14*, 519–654.

LARDY, CH. (1832): *Sur les Belemnites de la Nufenen.* Actes Soc. helvetique des Sci. Nat., p. 92.

LOVE, L. G. (1957): *Micro-organisms and the presence of syngenetic pyrite.* Quart. J. geol. Soc. Lond. *113*, 429–440.

LOVE, L. G. (1962): *Further studies on micro-organisms and the presence of syngenetic pyrite.* Palaeontology. Lon. *5*, 444–459.

LOVE, L. G. & MURRAY, J. W. (1963): *Biogenic pyrite in recent sediments of Christchurch Harbour, England.* Amer. J. Sci. *261*, 433–448.

LOVE, L. G. & ZIMMERMAN, D. O. (1961): *Bedded pyrite and micro-organisms from the Mount Isa shale.* Econ. geol. *56*, 873–896.

MEIER, P. & NABHOLZ, W. K. (1949): *Die mesozoische Hülle des westlichen Gotthard-Massivs im Wallis.* Eclogae geol. Helv. *42*/2, 197–214.

MOORE, R. C., LALICKER, C. G. & FISCHER, A. G. (1952): *Invertebrate Fossils.* McGraw-Hill.

NABHOLZ, W. K. (1945): *Geologie der Bündnerschiefergebirge zwischen Rheinwald, Valser- und Safiental.* Eclogae geol. Helv. *38*/1, 1–120.

SALOMEN, W. (1911): *Arietites sp. im schieferigen Granat-führenden Biotit-zoisit-Hornfels der Bedretto-Zone des Nufenen-Passes (Schweiz).* Verh. Naturhist.-Mediz. Ver. Heidelberg N.F. 11.

SCHMIDT, C. (1891): *Beiträge zur Kenntnis der im Gebiete von Blatt XIV der Geologischen Karte der Schweiz in 1:100000 auftretenden Gesteine.* Beitr. zur Geol. Karte der Schweiz. Anhang zu *25*, 1–77.

SCHMIDT, C. (1907): *Über die Geologie des Simplongebietes und die Tektonik der Schweizeralpen.* Eclogae geol. Helv. *9*/4, 484–584.

SCHMIDT, C. & PREISWERK, H. (1908): *Erläuterungen zur geologischen Karte der Simplongruppe 1:50000 Geol. Karte der Schweiz.* Erläuterungen Nr. 6, herausgeg. von der Schweiz. Geol. Komm.

STAPFF, F. M. (1892): *Remarks on Prof. Bonney's paper «On the crystalline schists and their relation to the Mesozoic rocks in the Lepontine Alps».* Geol. Mag. Dec. 3. *9*, 6–21.

STELLA, A. (1904): *Sulla geologica della regione ossolana contigua al Sempione.* Boll. Soc. geol. ital. *23*, 84–88.

TRÜMPY, R. (1960): *Palaeotectonic evolution of the Central and Western Alps.* Bull. geol. Soc. Amer. *71*, 845–907.

WENK, E. (1955): *Eine Strukturkarte der Tessineralpen.* Schweiz. min. petrogr. Mitt. *35*/2, 311–319.

WENK, E. (1962): *Plagioklas als Indexmineral in den Zentralalpen.* Schweiz. min. petrogr. Mitt. *42*/1, 139–152.