

PRELIMINARY NOTES ON THE TECTONICS AND LITHOTYPES OF THE "VERRUCANO S.L." IN THE MONTICIANO AREA (SOUTHERN TUSCANY, ITALY) AND THE FINDING OF FUSULINIDS WITHIN THE M.TE QUOIO FM. (VERRUCANO GROUP)

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Key- words: "Verrucano s. l.", Polymict Metaconglomerate, Fusulinids, Latest Carboniferous-Early Permian, Triassic, Tuscany (Italy).

Riassunto. Il rilevamento geologico eseguito da EH nell'area compresa fra le località di Scalvaia e Ferriera nella Valle del Farma, presso Siena, ha messo in evidenza due zone che mostrano un diverso assetto strutturale, separate da una faglia diretta, immergente ad ovest lungo un allineamento NNE-SSO. Nella zona occidentale la successione affiorante è costituita dal basso verso l'alto dalla parte superiore del "Verrucano", dalla Formazione di Tocchi e dal Calcare Cavernoso, cui seguono terreni recenti; nella parte orientale sembrano invece presentarsi in successione la Formazione di Risanguigno e l'intero Gruppo del "Verrucano s.l." (Formazione di Poggio al Carpino, Fm. di M.te Quoio e Verrucano superiore) che mostrano una vergenza verso est e struttura imbricata. La composizione e la granulometria del metaconglomerato di M.te Quoio sono state ricavate dall'analisi di una superficie di 550 cm² parallela alla stratificazione. Accurate indagini compiute su questa formazione in località Ferriera, hanno condotto al rinvenimento di due ciottoli di calcare rosso contenenti Fusulinidi. Gli esami delle microfacies eseguiti da PM hanno permesso di distinguere due tipi di associazioni. La prima, camp. EH 82-06-I, a *Pseudofusulina ascendens* Rauser, *Daixina* ? sp., *Eoparafusulina* (*Eoparafusulina*) cf. *ferganensis* (Dutkevitch), *E. (E.) parasolidia* (Bensch) ed *E. (E.) subcylindrica* (Bensch), è databile alla parte superiore del Carbonifero superiore (Gzheliano sup.) o alla parte bassa del Permiano inferiore (Asseliano). L'associazione del secondo ciottolo, camp. EH 82-06-II, comprendente *Staffella* ? spp., *Schubertella kingi* Dunbar & Skinner, *Boultonia* cf. *willisi* Lee e *Pseudofusulina paragregaria* Rauser, è invece certamente riferibile al Permiano inferiore. Raffronti vengono fatti particolarmente con le faune simili delle successioni alpine e russe e con il campione a *Parafusulinae* rinvenuto anni fa da Bodechtel (1964) nell'isola d'Elba.

Abstract. Geology of an area in the western part of the Monticiano-Roccastrada Range is shown below. Two zones, separated by a normal fault, are distinguished. Upper "Verrucano", Tocchi Fm. and Calcare Cavernoso, building up the western zone, form upright and broad folds. The eastern zone, comprising the Risanguigno Fm. and the "Verrucano s.l." Group (Poggio al Carpino Fm., M.te Quoio Fm., and Upper Verrucano), shows an east vergent, imbricated structure. In this zone, the Risanguigno Fm. seems to be conformly overlain by the Poggio al Carpino Fm.

Constituents and granulometry of a sample of polymict metaconglomerate of the M.te Quoio Fm. are described and two red limestone clasts (samples EH 82-06-I and EH 82-06-II) have been found within the meta-

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conglomerates of the M.te Quoio Fm., containing two different bioassociations with fusulinids, Uppermost Carboniferous (Latest Gzhelian)-Early Permian (Asselian) and Early Permian respectively. Identified fusulinids from sample EH 82-06-I belong to *Pseudofusulina ascedens* Rauser, *Daixina* ? sp., *Eoparafusulina* (*E.*) cf. *ferganensis* (Dutkevitch), *E. (E.) parasolida* (Bensh) and *E. (E.) subcylindrica* (Bensh) and to *Staffella* ? spp., *Schubertella kingi* Dunbar & Skinner, *Boultonia* cf. *willsi* Lee and *Pseudofusulina paragregaria* Rauser in sample EH 82-06-II.

These fusulinid faunas recognized for the first time in the Apenninic sequences seem to be correlated with Alpine and Russian coeval assemblages and they seem to confirm the previous finding of *Parafusulinae* by Bodechtel (1964) from the Elba Island.

Introduction.

In the course of the Antimony prospecting in Southern Tuscany conducted by the Institut für Allg. und Angew. Geologie, Abt. Geochemie und Lagerstättenkunde der LMU München under the supervision of Prof. Klemm (Klemm et al., 1982; Klemm, 1982; Dehm et al., 1983; Klemm & Neumann, 1984; Müller, 1985), EH mapped the area of Ferriera in the western part of the Monticiano- Roccastrada Range (1) (Fig. 1). The results are shown by EH and KDD in the next paragraph.

PM is the author of the notes on microfacies, fossils and chronostratigraphy of the samples with fusulinids and of the Systematics.

In the last fifty years, many authors described the geology of the Triassic and Pre-triassic sequences (and particularly of the "Verrucano s.l.") outcropping in the Monticiano-Roccastrada Range, SW of Siena.

Redini (1941) and Coccozza (1965) related to the Carboniferous some outcrops in the Farma valley near Monticiano, where the Carboniferous seems to be overlain "in apparent conformity by the Permo-Triassic Verrucano."

In the same locality, Signorini (1966) described a succession ranging from Carboniferous to Upper Triassic, in which Carboniferous slates and sandstones are overlain "with weak unconformity by the Verrucano."

Azzaro et al. (1976) proposed a new complete stratigraphy of the western Monticiano-Roccastrada Range. They instituted the Permian(?)-Triassic Ferriera Fm. which was interpreted as the accumulation of the eroded Hercynian geosynclinal sediments and which "unconformably passes up into the Middle Triassic Verrucano Group".

Coccozza et al. (1978) renamed the Ferriera Fm. as Poggio al Carpino Fm. because of synonymy with a previous instituted formation.

In the T. Farma area, the Verrucano Group described by Azzaro et al. (1976) consists of (from top to bottom) "fine grained anagenite and violet quartzite", M.te Quoio Fm. and Green quartzite, whereas Costantini et al. (1980) seem to attribute to the Verrucano Group the first ("Anageniti minute Fm.") and the second lithological unit only.

Up to the recent past, the age of the Verrucano Group in the Monticiano-Roccastrada Range could only be estimated as Middle to Late Triassic by means of the overlying Carnian Tocchi Fm. (Signorini, 1966; Costantini et al., 1980) and of the Skythian

(1) For his research in Tuscany EH got a grant from the Hans-Seidel-Stiftung of Munich.

to Early Anisian microfauna (*Meandrospira pusilla* (Ho), *Ammodiscus* aff. *parapriscus* Ho, *Tolypammima* cf. *gregaria* Wendt, *Calcitornella* (?) sp. and *Earlandia tintinniformis* (Misik)) found by Cocozza et al. (1975) within the reddish carbonate clasts of the M.te Quoio Fm. The source of these clasts is thought to be an Early-Middle Triassic carbonate platform of the Austroalpine Zone lying further to the west (Decandia et al., 1980). The fossiliferous clasts found by Cocozza et al. (1975) originate from rounded conglomerate boulders of the M.te Quoio Fm. present in the T. Farma river bed at Ferriera, a locality 5 km to the South of Monticiano (see Fig. 1).

Depositional environment and provenance of the clasts of the anagenites of the Tuscan Verrucano were described by Canuti & Saggi (1974).

The lithotypes of the "Middle to Upper Triassic Verrucano" of the Monticiano-Roccastrada Range show close resemblance to the Verruca Fm. of the "Verrucano tipico" of Northern Tuscany (Puxeddu et al., 1979).

Near Monticiano, Bagnoli & Tongiorgi (1979) found Early Devonian conodonts from layers attributed to the Boccheggiano Fm. by Cocozza et al. (1975). The sequence was tentatively designated as Risanguigno Fm.

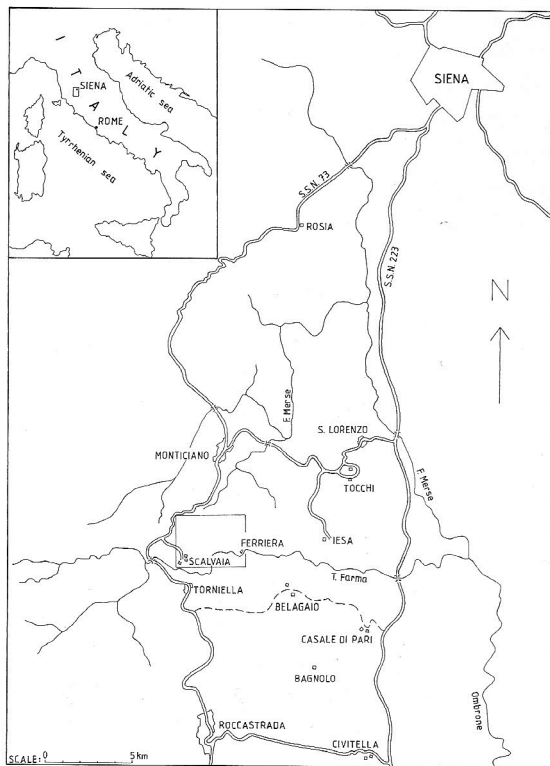


Fig. 1 - Location map of the Monticiano area and (small rectangle) of the geologic map of the Scalvaia-Ferriera area.

Recently, Martini et al. (1986) and Rau et al. (1987) recognized within the Verrucano of Punta Bianca (near la Spezia) in Northern Tuscany two transgressive cycles: the lower one of Anisian to Ladinian s. l. age that could be equivalent to the Poggio al Carpino Fm., and a second cycle starting in the Late Ladinian-Carnian, which should correspond to the Verrucano of the "Monti Pisani" and of other sites from Southern Tuscany.

In Tuscany, fusulinids have been found in the Monticiano-Roccastrada Range and in the Elba Island. Near Monticiano, in the T. Farma area, only Middle Carboniferous specimens have been found (Cocozza, 1965; Pasini, 1978, 1980). In the Elba Island, real Late Artinskian to Middle Permian *Parafusulinae* (Kahler & Kahler, 1968) were found by Bodechtel (1964) in the Upper Carboniferous to Permian Rio Marina Fm. (Vai, 1978; Bagnoli et al., 1980).

Tectonics and lithotypes of the "Verrucano s. l." from the Ferriera area.

Our recent geological survey of the Western Monticiano- Roccastrada Range allowed us to suggest a new tectonic interpretation of the Scalvaia-Ferriera area (Fig. 2).

In this area two zones, separated by a NNE-SSW striking, westward dipping normal fault, have been recognized (Fig. 2 and 3).

In the western zone, Middle to Late Triassic (Upper "Verrucano", Tocchi Fm. and Calcare Cavernoso) and Neogene/Quaternary sediments are exposed. The lithology of the Upper "Verrucano" (Ladinian-Carnian(?)) outcropping in this zone is briefly described as follows: fine grained, moderately sorted metaquartzconglomerates are interbedded with quartzites, metaquartzsandstones (fine to coarse grained; grey, pale green, bluish-grey and purple coloured), metasiltites and fine-sandy shales (bluish-grey and purple coloured). Rarely yellowish and redbrown carbonates (nodules and small lenses) are intercalated within the fine-clastic sediments. The bedding thickness of the metaquartzconglomerates ranges from 30 cm to 2 m. The colour of the quartzitic matrix varies between white to pink and purple. The bulk of the clasts is made up of white, grey, pink and reddish quartz. Secondary constituents: purple and bluish-grey metasiltites and metaquartzsandstones; grey-pink and white quartzites. Accessory tourmalinites occur. The grain size of the clasts seldom exceeds 5 cm.

The metamorphic mineral associations observed in thin sections of the "Verrucano" of this zone seems to be equivalent to the stage of "Very Low Grade Metamorphism" defined by Winkler (1979).

Bedding plane measurements indicate upright and broad anticlines and synclines. The b axes strike approximately NNW-SSE.

In the eastern zone, Middle Paleozoic (?) to Middle-Upper (?) Triassic formations [Risanguigno Fm.(?) and the "Verrucano s. l." Group (Poggio al Carpino Fm., M.te Quoio Fm. and Upper "Verrucano")] are exposed and they display a higher degree of deformation (Fig. 2,3).

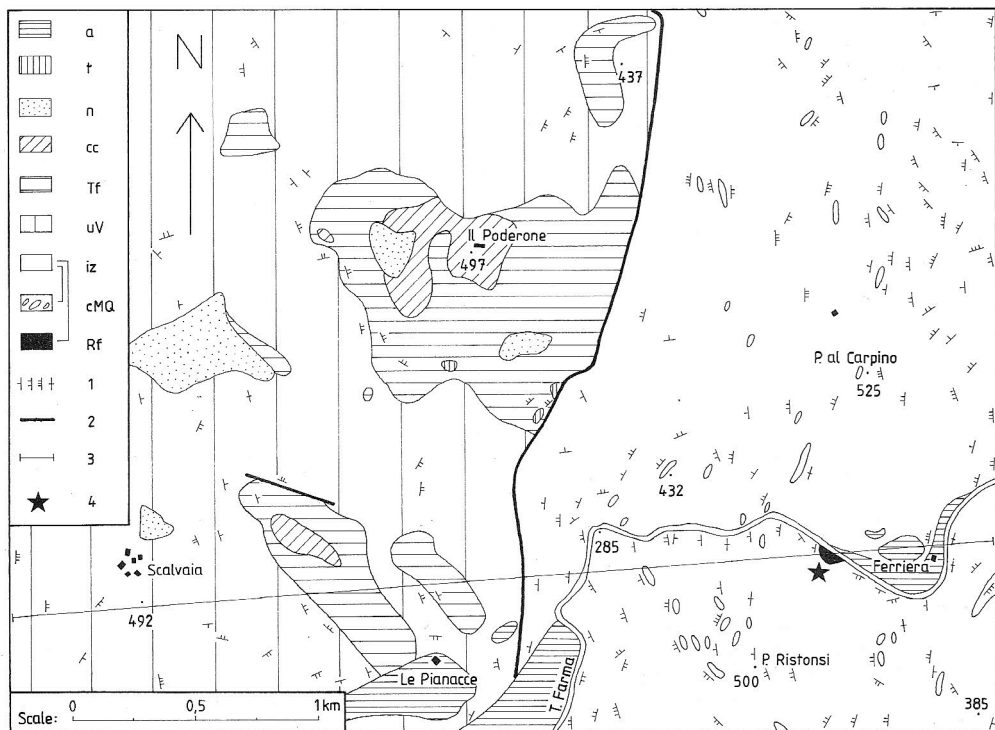


Fig. 2 - Geologic map of the Scalvaia-Ferriera area. Legend: a) River terraces; t) Travertine; n) Neoautochthonous (Pliocene); cc) Calcare cavernoso (Norian-Rhaetian); Tf) Tocchi Fm. (Carnian); uV) Upper Verrucano (Ladinian-Carnian?); iz) Imbricated zone (Paleozoic-Middle Triassic); cMQ) Conglomerate of M.te Quoio Fm. (Middle Triassic); Rf) Risanguigno Fm. (Early Devonian to?); 1) Strike and dip of bedding (from left to right: 1° - 29° ; 30° - 59° ; 60° - 89° ; vertical); 2) normal fault; 3) geologic section (see Fig. 3); 4) location of Fig. 4.

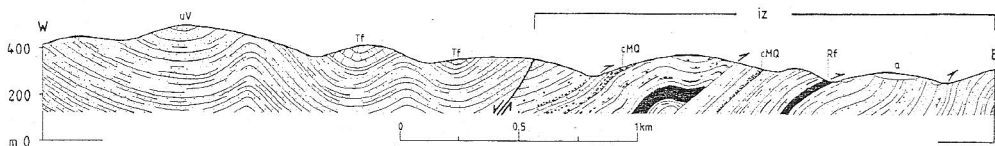


Fig. 3 - Schematic cross section from Scalvaia to Ferriera. Symbols as in Fig. 2.

Lithotypes comparable to the Risanguigno Fm., overlain by the Poggio al Carpino Fm., outcrop 450 m to the west of Ferriera along the southern bank of T. Farma. The sequence is shown in Fig. 4. The lithological sequence, probably belonging to the Risanguigno Fm., is as follows: fine to medium grained, dark-grey metasandstones up to 30 cm thick; black, finely laminated metasiltites; black shales with cherty intercalations on mm - scale; laminated (the thickness of the laminae ranges from 0,5 mm to 2 cm), white and grey cherts and lydites. The dolomites described from the type locality (Bagnoli et al., 1979) are not exposed. The formation seems to be conformably overlain by pale-greenish metasiltites and microconglomeratic metasandstones of the Poggio al Carpino Fm.

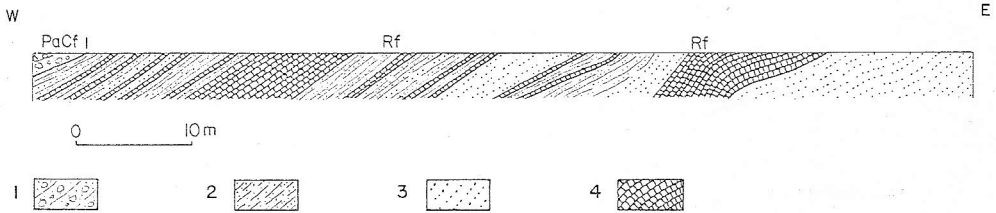


Fig. 4 - Geologic cross section of an outcrop 450 m. to the West of Ferriera (Fig. 2). Lithotypes referable to the Risanguigno Fm. (Rf) seem to pass upward in apparent conformity into the Poggio al Carpino Fm. (PaCf). 1) Conglomeratic metasandstones of the Poggio al Carpino Fm.; 2) dark-grey metasandstones with intercalations of black shales; 3) dark, laminated metasiltites and black shales; 4) laminated cherts and lydites.

In the lower part of the Poggio al Carpino Fm., light-grey, greenish and cream-coloured metasiltites, lenses of black shales with interstratified chert layers on mm-scale occur, and dominantly thick bedded, fine to coarse grained, white, grey, sometimes bluish-grey, discontinuously crosslaminated, multiple graded, partly carbonaceous metasandstones occur. The latter show lateral transitions to conglomeratic metasandstones and poorly sorted, polymict metaconglomerates. The clasts of the metaconglomerates consist of dark-grey to black, laminated metasiltites, white to dark-grey metaquartzsandstones, light-brown carbonaceous metasandstones, light-grey metamicroquartzconglomerates, yellow, grey and black carbonates, and white or grey quartz. The observed clast size does not exceed 40 cm.

The upper part of the Poggio al Carpino Fm. outcropping in the Ferriera area, is made up of white, oligomict metaconglomerates (clast size up to 14 cm; clasts: white quartz, subordinately light-grey quartzites), white to grey, microquartzconglomeratic metasandstones and quartzites, bluish-grey and grey-greenish laminated metasandstones, metasiltites and rarely partly silicified lenses of white, yellowish and light-grey carbonates.

The overlying M.te Quoió Fm. is made up of bluish-grey and purple, monotonous metasiltites, fine to coarse grained purple quartzites, metaquartzsandstones, and poorly sorted, polymict, thick-bedded metaconglomerates.

The lithotypes of clasts observed within the polymict metaconglomerates are summarized here (roundness and clast size are added in the following list):

- a) bluish-grey, fine sandy shales; angular to rounded in shape; clast size ≤ 15 cm;
- b) bluish-grey metasiltites; subrounded in shape; clast size ≤ 20 cm;
- c) purple, bluish-grey and light-grey, fine to coarse grained metasandstones, metaquartzsandstones and quartzites; subrounded to well rounded in shape; clast size ≤ 60 cm;
- d) grey-purple, small grained metaquartzconglomerates; rounded in shape; clast size ≤ 22 cm;
- e) white, oligomict metaquartzconglomerates; rounded in shape; clast size ≤ 45 cm;
- f) white and pink quartz; very angular to rounded in shape; clast size ≤ 2 cm;
- g) dark-red to purple coloured carbonates containing crinoids and fusulinids; subrounded to well rounded in shape; clast size ≤ 35 cm;
- h) reddish-brown, heavily recrystallized carbonates; not recognizable fossils; subrounded to well rounded in shape; clast size ≤ 1.2 m;
- z) reddish-brown, colitic carbonates; rounded in shape; clast size ≤ 8 cm;
- j) light-yellow carbonates containing not recognizable gastropods or polychaeta; subrounded to well rounded in shape; clast size ≤ 40 cm;
- k) light-yellow, oolitic carbonates; angular to rounded in shape; clast size ≤ 7 cm;
- l) hematitic cherts; subrounded in shape; clast size ≤ 7.5 cm;
- m) reddish brown shales; rounded in shape; clast size ≤ 12 cm;
- n) tourmalinites; rounded to well rounded in shape; clast size ≤ 2.2 cm;
- o) grey-pink quartz porphyry; rounded to well rounded in shape; clast size ≤ 6 cm.

The lithology of the Upper "Verrucano" of the eastern zone is very similar to that of the "Verrucano" of the western zone.

In the eastern zone our survey indicates an imbricated east vergent structure. Small scale isoclinic anticlines were frequently observed. The stage of "Low Grade Metamorphism" was probably attained in this zone. This might be indicated by the appearance of chloritoid (Winkler, 1979, p. 215) in thin sections (this mineral was never found in thin sections of the "Verrucano" of the western zone).

Detailed granulometric study of a M.te Quoiò metaconglomerate sample.

On a plane cut (size 550 cm^2) approximately parallel to the bedding plane of a polymict metaconglomerate-stratum found at Ferriera, all clasts larger than 2 mm were counted (total number 340) and analyzed. The following percentages of the total number have been obtained:

- 1) White, grey and pink quartz (4%);
- 2) White and grey quartzites (48%);
- 3) Carbonates (13%);
- 4) Bluish-grey metasandstones (30%);
- 5) Bluish-grey fine sandy shales (3%);
- 6) Metamicroquartzconglomerates (2%).

The relation between size and roundness of the clasts, which were deposited in a fluvial environment according to Canuti and Sagri (1974), is shown in Fig. 5. The posi-

tive correlation visible in histograms 1, 2, 4 and 5 can easily be explained by supply from one single source.

The significant reduction of roundness between 16-32 mm in histogram 3 (carbonates) may be interpreted in different ways: the carbonate clasts were derived from two sources at different distance, or from two different levels of a single source area.

Unfortunately the thin sections of the carbonate clasts of histogram 3 yielded no biostratigraphic indications, preventing any better interpretation.

Polymict metaconglomerates containing red carbonate clasts were observed at several sites quoted as follows: 1) 60 m east of P 285; 2) 300 m ESE of Ferriera at 340 m elevation; 3) 80 m east of the confluence of Rio Paiolo and T. Farma. Thin sections of the carbonate clasts sampled in those locations were barren.

Microfacies, fossils and chronostratigraphic references.

The subangular pebbles of red limestone with fusulinids found by E.H. during his researchs on the boulders of M.te Quoio metaconglomerates of the Ferriera area, are only two; their dimensions are 8 cm. (sample EH 82-06-I) and 5 cm (sample EH 82-06-II) respectively (1).

The microfacies are constituted by red-purple and red packstone, and two fossiliferous assemblages are represented as follows:

- Sample EH 82-06-I; thin sections F1, F2, F3, F4, F6, F7, F8, F9, F10, F11, F12, F13, F14, F15.

Red-purple packstone with Algae (*Epimastopora*), crinoids, fenestrate bryozoa, and foraminifers belonging only to the following fusulinids: *Eoparafusulina* (*E.*) cf. *ferganensis* (Dutkevitch) (Pl. 49, fig. 5), *E. (E.) parasolida* (Bensh) (Pl. 49, fig. 4), *E. (E.) subcylindrica* (Bensh) (Pl. 49, fig. 6b), *Pseudofusulina ascedens* Rauser (Pl. 49, fig. 6a) and *Daixina* ? sp.

This association belongs to the Uppermost Carboniferous (Uppermost Gzhelian) - Lower Permian (Asselian to (?) Lower Artinskian) and it is correlatable with the same associations of the Southern Alps (Kahler & Kahler, 1980; Kahler, 1983, 1985) and of the URSS (Tchuvashov et al., 1986).

- Sample EH 82-06-II; only one large thin section, F16.

Red packstone with many algal remains (*Epimastopora*, *Eflugelia*, and *Anchicodium*), gastropods, crinoids, small fragments of non - fenestrate bryozoa and abundant foraminifers belonging to the genera *Chymacamina*, *Ammodiscus*, *Tetrataxis* and to the following fusulinids: *Staffella* ? spp., *Schubertella kingi* Dunbar & Skinner (Pl. 49, fig. 1), *Boultonia* cf. *willsi* Lee (Pl. 49, fig. 2), *Pseudofusulina paragregaria* Rauser (Pl. 49, fig. 3).

The age of this sample seems to be Early Permian as the South - Alpine Trogkofel limestone where the same association of fusulinids (especially *B. willsi* and *P. paragre-*

(1) Another small pebble without foraminifers, but with the same algal, bryozoan and crinoidal association of the sample EH-82-06-I has been recently found by PM at Ferriera, within the M.te Quoio Fm.

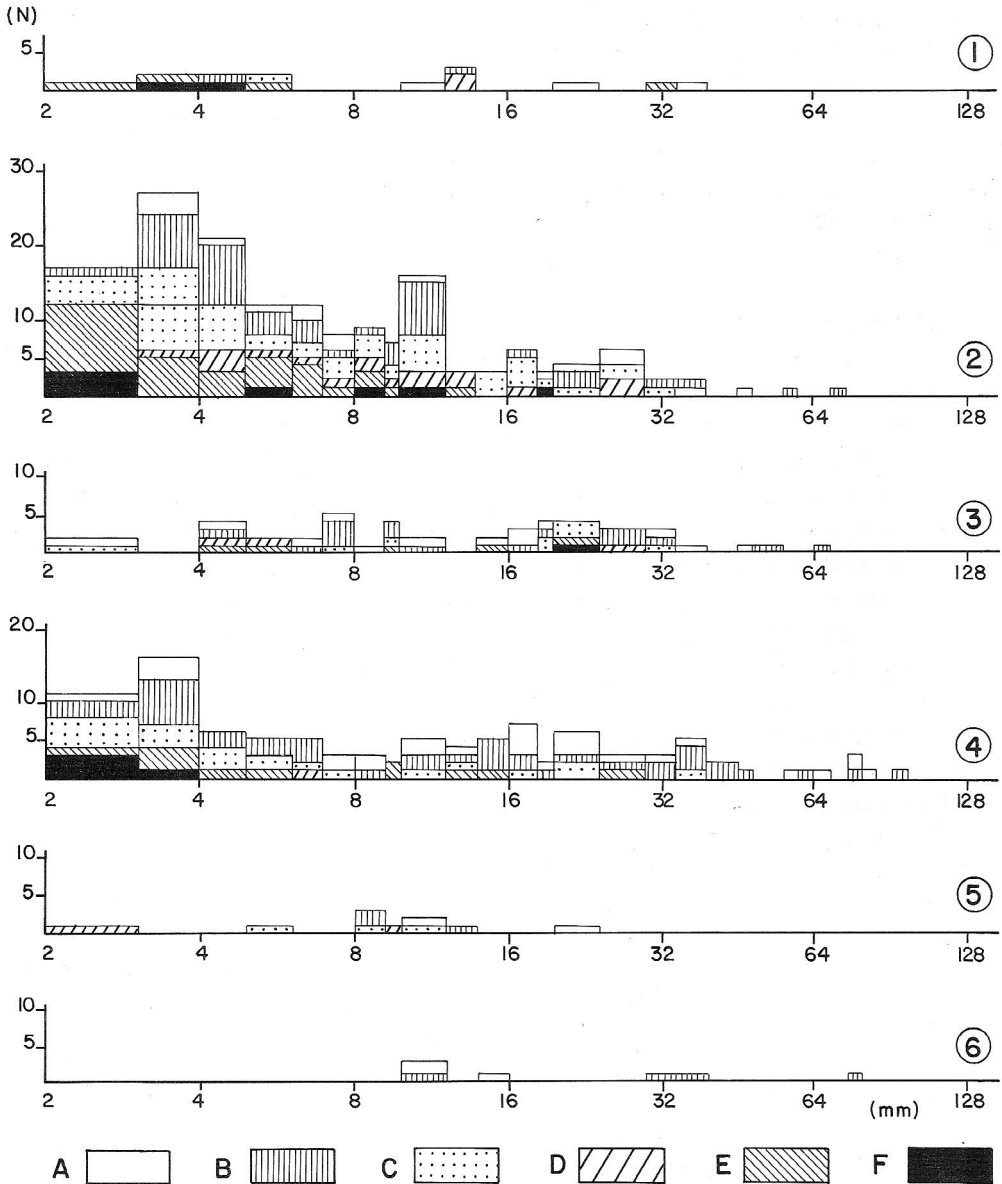


Fig. 5 - Example of relation between size and roundness of six types of clasts: 1-White, grey and pink quartz; 2-White and grey quartzites; 3-Carbonates; 4-Bluish-grey metasandstones; 5- Bluish-grey, fine sandy shales; 6-Metamicroquartzconglomerates within polymict metaconglomerates of the M.te Quoio Fm.

Ordinate: Number of clasts (N). Abscissa: Clast size intervals (mm) on logarithmic scale.

Symbols: A) well rounded; B) rounded; C) subrounded; D) subangular; E) angular; F) very angular.

garia) and Algae is found. Similar assemblages are also known from the european URSS.

The finding of those two pebbles has a particular relevance for the newness and for the area of discovery.

In the foreword we showed that the above mentioned associations have never been found, up to now, neither in the outcrop, nor in boreholes (as far as we know) in the Apennine region. The only finding similar to the eoparafusulinid assemblage is that of Bodechtel (1964) from the Elba Island. In the past, this finding was doubted (Perrin, 1974; Pasini, 1982), but fusulinid fauna found now in the M.te Quoio Fm. dispels these doubts. However, the two set of samples have a different age, because of the presence of true final Artinskian *Parafusulinae* in Bodechtel's one (Kahler & Kahler, 1969; Kahler, 1974), whereas the genus *Eoparafusulina*, found in the EH's samples, is the oldest among the schwagerinid genera evolving in *Parafusulina*.

The stratigraphic range of the subgenus *Eoparafusulina* (E.) (? = *Ruzbenzevites* Davydov, 1980) (see Systematics) is Uppermost Carboniferous (Uppermost Gzhelian) - Lowermost Permian (Asselian to (?) Lowermost Artinskian) in the Southalpine and Russian sequences and only Lowermost Permian (Wolfcampian and Wolfcampian-Leonardian boundary) in North America (Ross, 1967; Mc Guban, 1983).

Dimensions of our *Eoparafusulinae* seem to be smaller than those of the Russian and Alpine specimens (see Systematics) and they are closer to the North American forms. Such a character could be due to possible provincialism.

As we have seen, the fossil associations, found in the EH's samples and their age, show better connections with the Southalpine and Russian basins, and possibly perhaps with the Elba series, than with the other Carboniferous to Permian (?) sequences of Southern Tuscany. Hitherto all researchs achieved by italian and foreign geologists on the Verrucano Group have not lead to find pebbles with the marine Middle Carboniferous assemblages (Cocozza, 1965; Pasini, 1980) of the Farma Valley.

Systematics (1)

Ord. Fusulinida Fursenko, 1958

Fam. *Staffellidae* Miklucho-Maklay, 1949

Subfam. *Staffellinae* Miklucho-Maklay, 1949

Gen. *Staffella* Ozawa, 1925

***Staffella* ? spp.**

Some small fusulinids from the thin section F16 (sample EH 82- 06-II) are attributed with uncertainty to this genus. Different, nearly axial sections suggest the pre-

(1) Systematics follow Kahler & Kahler (1966-67).

sence of different species, but the recrystallization is too strong to permit a correct identification.

Staffella is a Permian genus. However, other Carboniferous and Permian *Staffellidae* (sensu Rozovskaya, 1975), like *Pseudoendothyra* Mikhailov, *Nankinella* Lee and *Sphaerulina* Lee, can show similar outlines.

Fam. *Schubertellidae* Skinner, 1931

Subfam. *Schubertellinae* Skinner, 1931

Gen. *Schubertella* Staff & Wedekind, 1910

***Schubertella kingi* Dunbar & Skinner, 1937**

Pl. 49, fig. 1

1937 *Schubertella kingi* Dunbar & Skinner, pp. 610-611, pl. 45, fig. 10-15.

1959 *Schubertella kingi* - Kochansky Devidé, pp. 17-18 and 47, pl. 1, fig. 7-12.

1965 *Schubertella kingi* - Skinner & Wilde, p. 25, pl. 27, fig. 4-11.

1966 *Schubertella kingi* - Kahler & Kahler, p. 205.

1970 *Schubertella kingi* - Kochansky Devidé, p. 190, pl. 3, fig. 16-18.

1980 *Schubertella* ex. gr. *kingi* Kahler & Kahler, p. 188.

1983 *Schubertella kingi* - Kahler, p. 33, pl. 1, fig. 5.

Sample EH 82-06-II, section F16.

A fragment of an axial section, lacking of a polar region, resembles very closely the typical forms and chiefly fig. 4 and 7 of Skinner & Wilde (1965), fig. 10 of Kochansky Devidé (1959) and fig. 5 of Kahler (1983).

Dimensions (in mm):

Diameter of proloculus: 0.022

Whorls	Length (1/2 Lx2)	Diameter	Ratio
I	0.050	0.045	1.1
II	0.120	0.088	1.3
III	0.340	0.150	2.2
IV	0.720	0.230	3.1

S. kingi and related forms (Kahler & Kahler, 1980) are widespread in the boreal hemisphere in the Latest Carboniferous and in the Early Permian.

Subfam. *Boultoniinae* Skinner & Wilde, 1954

Gen. *Boultonia* Lee, 1927

***Boultonia* cf. *willsi* Lee, 1927 ("sensu Auctorum") (Kahler & Kahler, 1980)**

Pl. 49, fig. 2

In the microfacies of the sample EH 82-06-II, section F16, there are many small *Boultonia*. The figured one is a transversal section through the proloculus. The very thin diaphanothecal spirotheca and the coiling of the juvenarium are typical of the genus. Dimensions and ratio are close to *B. willsi* (Lee, 1927, pl. 2, fig. 1-4) as well as the narrow and low chomata in the II and III volutions. The strong fluting of the septa in the axial region which characterizes *B. willsi* seems to be present at the extreme right polar region only, probably due to the cut of the section.

Dimensions (in mm):

Whorls	Length	Diameter	Ratio
I	0.12	0.10	1.2
II	0.37	0.13	2.8
III	0.68 ?	0.20	3.4 ?
IV	1.30 ?	0.32 ?	4 ca.

B. willsi Lee is widespread all over the marine Lower Permian (Kahler & Kahler, 1980).

Fam. *Schwagerinidae* Dunbar & Henbest, 1930

Subfam. *Schwagerinnae* Dunbar & Henbest, 1930

Gen. "*Pseudofusulina* Dunbar & Skinner, 1931

– *Pseudofusulina* (im sowjet. Sinne) Kahler & Kahler, 1966, p. 577"

***Pseudofusulina paragregaria* Rauser, 1940**

Pl. 49, fig. 3

1940 *Pseudofusulina paragregaria paragregaria* Rauser Chernousova, pp. 81-82 (russ.), p. 93 (engl.), pl. 2, fig. 4-7.

1966 *Pseudofusulina paragregaria paragregaria* - Kahler & Kahler, p. 608.

1985 *Pseudofusulina paragregaria paragregaria* - Kahler, p. 65, pl. 6, fig. 3.

1986 *Pseudofusulina paragregaria paragregaria* - Tchuvashov, Leven & Davydov, p. 75, pl. 8, fig. 12,13.

1986 *Rugosochusenella paragregaria* - Tchuvashov, Leven & Davydov, p. 123, pl. 25, fig. 16.

Sample EH-82-06-II, section F16.

Transversal section through the proloculus probably belonging to *P. paragregaria* Rauser (Kahler, 1985, p. 65, pl. 6, fig. 3; Tchuvashov et al., 1986, p. 75, pl. 8, fig. 12,13).

Shell subelliptical-fusiform with bluntly rounded 7-7.5 volutions of a gradually enlarged spire of the keriothecal spirotheca; 5.50 mm (?) in length and 1.75 mm in width (ratio=2.5 ?); septa irregularly and moderately fluted from pole with folds mainly confined to the axial area. Very minute chomata in the first volutions.

The regular coiling of the spirotheca in the inner volutions in our specimen and the lack of rugosity exclude it from the genus *Rugosochusenella* Skinner & Wilde, 1965.

Those characteristics and the lack of axial fillings seem to distinguish it, at the specific rank, from *Pseudofusulina ascedens* (see below).

P. paragregaria Rauser is found in European USSR and in the Southern Alps in the Early Permian.

***Pseudofusulina ascedens* Rauser, 1940**

Pl. 49, fig. 6a

1940 *Pseudofusulina paragregaria* subsp. *ascedens* Rauser Chernousova, pp. 82-83 (russ.), p. 93 (engl.), pl. 2, fig. 8 - 10.

1966 *Pseudofusulina* (im sowjet. Sinne) *paragregaria ascedens* - Kahler & Kahler, p. 608.

1985 *Pseudofusulina* (im sowjet. Sinne) *paragregaria ascedens* - Kahler, p. 66, pl. 6, fig. 4-6.

1986 *Rugosochusenella ascedens* - Tchuvashov, Leven & Davydov, p. 103, pl. 16, fig. 16.

Sample EH 82-06-I, section F14.

Shell of small dimensions; section parallel to the axial plane showing 5 to 5.5 volutions of the keriothecal spirotheca. Inner whorls seem to be coiled tighter than the outer ones. Rugose spirotheca in the external volution; broad chomata in the inner whorls; axial fillings in the axial and polar regions.

Our specimen is very close to the Kahler's one (1985, pl. 6, fig. 4). The lack of the rugose spirotheca in the inner whorls associated with the presence of chomata seem to exclude this specimen from both the genera *Chusenella* Hsu (Stewart, 1963, p. 1153) and *Rugosochusenella* Skinner & Wilde (Tchuvashov et al., 1986).

P. ascedens Rauser is found at the end of the Carboniferous sequences and in the Early Permian in the Carnic Alps, in the USSR (starting from the *Daixina bosbytauensis* - *D. robusta* zone; Tchuvashov et al., 1986), Iran and North China (Kahler, 1985).

Gen. *Daixina* Rozovskaya, 1949

***Daixina* ? sp.**

Sample EH 82-06-I, section F14.

Fragment of a transverse section of a fusulinid of medium size L = 5 mm through a large proloculus (diameter = 0.35 mm). The last volution (V) of the thick keriothecal spirotheca shows disordered and low septal folds concentrated towards the polar regions. Chomata lacking.

The genus *Daixina* is known in the Latest Carboniferous (Gzhelian) and in the Earlier Permian (Asselian) of the European and Asiatic basins. However, some North American pseudofusulinids of American Authors may belong to this genus (Rozovskaya, 1975).

Gen. *Eoparafusulina* Coogan, 1960, emend. Skinner & Wilde, 1965

Eoparafusulina is one of the Latest Carboniferous - Early Permian schwagerinid genera trending towards *Parafusulina* Dunbar & Skinner, 1931.

Ross (1967), on the base of different "ratio", recognized two subgenera: *Eoparafusulina* with ratio 3.5; *Mccloudia* with ratio 3.

Eoparafusulinids show moderate dimensions, cylindrical or subcylindrical shape, proloculus minute, keriothecal spirotheca regularly coiled, septa regularly fluted from pole to pole, septal folds developed only in the lower half of the septa, cuniculi in the early stage only in outer volutions, phrenothecae missing.

Among the genera trending towards *Parafusulina*, the more similar to *Eoparafusulina* (particularly to nominotypical subgenus) are *Praeparafusulina* Tumanskaya, 1962 and *Ruzhenzevites* Davydov, 1980 (Tchuvashov et al., 1986). *Praeparafusulina* differs from *Eoparafusulina* in having phrenothecae and septal folds extending up to the top of the septa.

Ruzhenzevites resembles so closely *Eoparafusulina* that it seems to be a junior synonym.

Both *Eoparafusulina* (= ? *Ruzhenzevites*) and *Praeparafusulina* have a "pseudofusulinid" shape. The fundamental characteristic to distinguish them from *Pseudofusulina* Dunbar & Skinner, 1931 is the presence of primitive cuniculi in the outer volutions. These cuniculi are observable only in casual tangential or diagonal sections. Cuniculi in primitive stage have also been observed in some specimens belonging to various other genera (for ex. *Quasifusulina* Chen and *Paratriticites* Kochansky Devidé (Kochansky Devidé, 1969)).

In our opinion, primitive cuniculi in outer volutions should not be a distinctive character to the generic rank.

***Eoparafusulina* (*Eoparafusulina*) cf. *ferganensis* (Dutkevitch, 1939)**

Pl. 49, fig. 5

Sample EH 82-06-I, section F13.

Slightly oblique section through an irregularly large proloculus.

Shell moderately small and elongate cylindrical shape. 4 whorls of the keriothecal spirotheca having roughnesses in the IV volution. Chomata only in the proloculus and in the first whorl.

Dimensions (in mm):

Diam. prol. = 0.200

Whorls	Length	Diameter	Ratio
I	1.10	0.50	2.2
II	2.45	0.80	3.0
III	4.50	1.15	4.0
IV	6.40	1.40	4.5

Shape and ratio very close to *Schwagerina pailensis* var. *ferganensis* Dutkevitch, 1939 (p. 47, pl. 5, fig. 1) the type species of *Ruzhenzevites* Davydov. Number of volutions and dimensions smaller than in all mature specimens reported by the Authors for the species of this group. In Kahler's opinion, our specimen could be a megalosphaeric form.

External rugose wall remind of the sole illustration we know (description is missing) of "*Ruzhenzevites ferganensis rugosa*" Davydov (Tchuvashov et al., 1986, pl. 20, fig. 3)

Ruzhenzevites praeferganensis Davydov, 1986 (Tchuvashov et al., 1986, p. 112, pl. 20, fig. 6,7) has 5-6 volutions, larger dimensions and smaller ratio.

Fusulinids belonging to this group are found in the URSS in the Latest Carboniferous (Gzhelian) in the *Ruzhenzevites ferganensis* - *Pseudofusulina malkovskiyi* zone (Tchuvashov et al., 1986). "*Pseudofusulina*" *ferganensis* has been found by Kahler & Kahler (1980, p. 216, pl. g, fig. 9) in the alpine Early Permian.

Eoparafusulina (Eoparafusulina) parasolida (Bensh, 1962)

Pl. 49, fig. 4

1962 *Pseudofusulina* (?) *parasolida* Bensh, pp. 246-247, pl. 23, fig. 1,2.

1966 *Pseudofusulina* ? (im sowjet. Sinne) *parasolida* - Kahler & Kahler, p. 611.

1972 *Pseudofusulina* (im sowjet. Sinne) *parasolida* - Bensh, pp. 129-130, pl. 28, fig. 8; pl. 29, fig. 2.

1983 *Pseudofusulina* (im sowjet. Sinne) *parasolida* - Kahler, pp. 82-83, pl. 8, fig. 2.

1986 *Ruzhenzevites parasolidus* - Tchuvashov, Leven & Davydov, p. 112, pl. 20, fig. 5.

Sample EH 82-06-I, section F2.

Incomplete axial section. Dimensions and shape are very close to the inner three whorls of the specimen figured by Kahler (1983) from the alpine Uppermost Gzhelian.

Among the species belonging the *Eoparafusulina* (*Eoparafusulina*), *E. parasolida* is characterized by the ratios and by the massive axial fillings of the II-III volutions.

Dimensions (in mm):

Diam. prol. = 0.190

Whorls	Length	Diameter	Ratio
I	1.4	0.52	2.6
II	3.0	0.91	3.2
III	5.2	1.20	4.3

Fusulinids belonging to this species have been found in the Uralian and Asiatic USSR in the *Ruzhenzevites ferganensis* - *Pseudofusulina malkovskiyi* zone (Latest Carboniferous) immediately below the *Daixina bosbytauensis* - *D. robusta* zone (Earliest Permian) (Tchuvashov et al., 1986).

Eoparafusulina (Eoparafusulina) subcylindrica (Bensh, 1972)

Pl. 49, fig. 6b

1972 *Pseudofusulina subcylindrica* Bensh, pp. 126-127, pl. 28, fig. 6,7.1986 *Ruzhenzevites subcylindricus* - Tchuvashov, Leven & Davydov, p. 112, pl. 20, fig. 2.

Sample EH 82-06-I, section F14.

Very large oblique and paraaxial sections of schwagerinid probably belonging to this species are present in some slides of the sample.

The figured specimen, sectioned through the proloculus, is a small-medium sized, typical form for the ratio L/D whorl by whorl and for the ratio between two whorls in succession.

Dimensions (in mm):

Diam. prol. = 0.125

Whorls	Length	Diameter	Ratio
I	0.80	0.35	2.2
II	1.60	0.52	3.0
III	2.20	0.80	2.7
IV	5.40	1.10	4.9
V	9.0 ca.	1.50 ca.	6.0 ca.

This species is only mentioned in the Latest Gzhelian of the USSR below the *Daixina bosbytauensis* - *D. robusta* zone, just below the Carboniferous-Permian boundary.

Acknowledgments.

We wish to thank F. Kahler for his advice on some specimens of fusulinids and F.A. Decandia for his discussions on the regional tectonics.

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PLATE 49

- Fig. 1 - *Schubertella kingi* Dunbar & Skinner. Axial section (fragment). Sample EH 82-06-II, sect. F16; x 80.
- Fig. 2 - *Boultonia* cf. *willsi* Lee. Transversal section through the proloculus. Sample EH 82-06-II, sect. F16; x 20.
- Fig. 3 - *Pseudofusulina paragregaria* Rauser. Transversal section. Sample EH 82-06-II, sect. F16; x 20.
- Fig. 4 - *Eoparafusulina (Eoparafusulina) parasolida* (Bensh). Slightly oblique axial section. Sample EH 82-06-I, sect. F2; x 20.
- Fig. 5 - *Eoparafusulina (Eoparafusulina) cf. ferganensis* (Dutkevitch). Slightly oblique axial section. Sample EH 82-06-I, sect. F13; x15.
- Fig. 6 - Packstone with crinoidal fragments and fusulinids:
 a) *Pseudofusulina ascedens* Rauser;
 b) *Eoparafusulina (Eoparafusulina) subcylindrica* (Bensh).
 Sample EH 82-06-I, sect. F14; x 15.

