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STRATIGRAPHY AND PETROGRAPHY OF UPPER PERMIAN TO ANISIAN TERRIGENOUS WEDGES (VERRUCANO LOMBARDO, SERVINO AND BELLANO FORMATIONS; WESTERN SOUTHERN ALPS)

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Key-words: Southern Alps, Stratigraphy, Permian, Scythian, Anisian, Sandstone petrography, Petrofacies.

Riassunto. I parametri composizionali di 184 campioni di arenarie provenienti dalla successione permo-anisica del Sudalpino occidentale si raggruppano in 8 intervalli petrologici, che corrispondono a pacchi di strati sovrapposti e correlabili lateralmente. Le variazioni composizionali riflettono in primo luogo l'interazione di tettonica ed erosione delle aree sorgenti nel tempo. La distruzione selettiva di frammenti di roccia instabili in ambienti marini poco profondi e di alta energia giustifica solo variazioni composizionali minori, nell'ambito di intervalli trasgressivi, facies eteropiche e ciclotemi ad alta frequenza. Altri fattori, climatici e diagenetici, hanno avuto un effetto apparentemente subordinato sulle mode detritiche.

Vengono riconosciuti quattro stadi principali nell'evoluzione geodinamica Permo-Anisica dell'area studiata. (1) Le unità clastiche dal Permiano Superiore al Griesbachiano (Verrucano Lombardo e Membro di Prato Solaro del Servino, qui introdotto per la prima volta) documentano una graduale diminuzione del rilievo, con progressivo smantellamento dei plateaux ignimbritici del Permiano Inferiore e sempre più importante esumazione del basamento Ercinico e delle sue coperture clastiche aporfiriche. (2) La grande trasgressione tardo-griesbachiana, datata per mezzo del Bivalve *Claraia intermedia*, portò alla deposizione di un corpo tabulare di arenarie quarzose mature (litozona mediana del Servino). (3) In prossimità del limite Smithiano-Spathiano, prismi arkosici di scarsa continuità laterale, cui seguono dolomie e siltiti di ambiente marino aperto (litozona superiore del Servino), si depositarono in fan-delta. Questi erano alimentati da rocce granitoidi sollevate a occidente nel corso di un evento tettonico testimoniato anche in altri siti delle Alpi Meridionali ("Fase" Recoarese). (4) Dal limite Scitico-Anisico all'Illirico, una ripresa nella progradazione dei fan-delta (Formazione di Bellano) arricchiti in detrito non solo proveniente dal basamento ma anche di origine vulcanica, suggerisce un'inversione tettonica di bacini "tipo Collio" colmati da ignimbriti Permiane ("Fase" Montenegrina); non possiamo escludere però un'attività magmatica coeva.

Terrigeni anisici localmente paraconcordanti su pochi metri di subarkose del Servino sono stati riconosciuti, grazie all'analisi petrografica, anche tra il Lago di Como e il Lago di Lugano. Questi affioramenti erano stati in precedenza descritti con il termine improprio di "Servino-Verrucano Serie".

Abstract. Detrital modes of 184 sandstone samples from the Upper Permian to Upper Anisian succession of the western Southern Alps group in 8 petrologic intervals, corresponding to superposed and laterally correlatable packages of strata. Compositional trends largely mirror the complex interplay of tectonism and erosion of source rocks through time. Selective destruction of unstable rock fragments in high-energy shallow-marine environments only accounts for minor mineralogical changes within transgressive intervals, interfingering lithofacies and high-frequency cyclothems. Other factors, such as climate and diagenesis, seemingly had a subordinate effect on detrital modes.

Four major steps in the Permo-Anisian geodynamic evolution are inferred. (1) The Upper Permian to Griesbachian clastics (Verrucano Lombardo and Prato Solaro Member of the Servino Formation - herein introduced) document gradual reduction of relief, with progressive dissection of the Lower Permian ignimbritic plateaux and unroofing of Hercynian basement rocks with their aporphyric siliciclastic cover. (2) The major latest Griesbachian transgression, dated with the pelecypod *Claraia intermedia*, led to deposition of a tabular body of mature quartzose sandstones (middle lithozone of the Servino Formation). (3) Close to the Smithian-Spathian boundary, laterally confined arkosic wedges overlain by open marine mudrocks (upper lithozone of the Servino Formation) were deposited in fan-deltas fed by granitoid basement rocks uplifted during a tectonic event widespread in the Southern Alps (Recoaro "Phase"). (4) From around the Scythian-Anisian boundary to the Illyrian, renewed progradation of fan-deltas (Bellano Formation), enriched not only in basement-derived detritus but also in volcanic rock fragments, points to tectonic inversion of Collio-type basins (Montenegro "Phase"); coeval magmatic activity cannot be ruled out. Anisian siliciclastics locally underlain by a few meters of mid-Servino subarkoses are recognized through quantitative petrographic analysis also between Lake Como and Lake Lugano. These outcrops were previously described under the inappropriate term "Servino-Verrucano Series".

Introduction.

A largely terrigenous succession spanning from the Upper Permian to the Anisian is exposed - east to west - between the Brembana Valley and Lugano (Fig. 1). Two main structural domains characterize the area east of Lake Como: the Orobic Anticline, east of Taceno, and the Northern Grigna, where the sedimentary succession non-conformably overlies the Hercynian Orobic basement (Fig. 2). The western limb of the Orobic Anticline plunges steeply underneath the Orobic ba-

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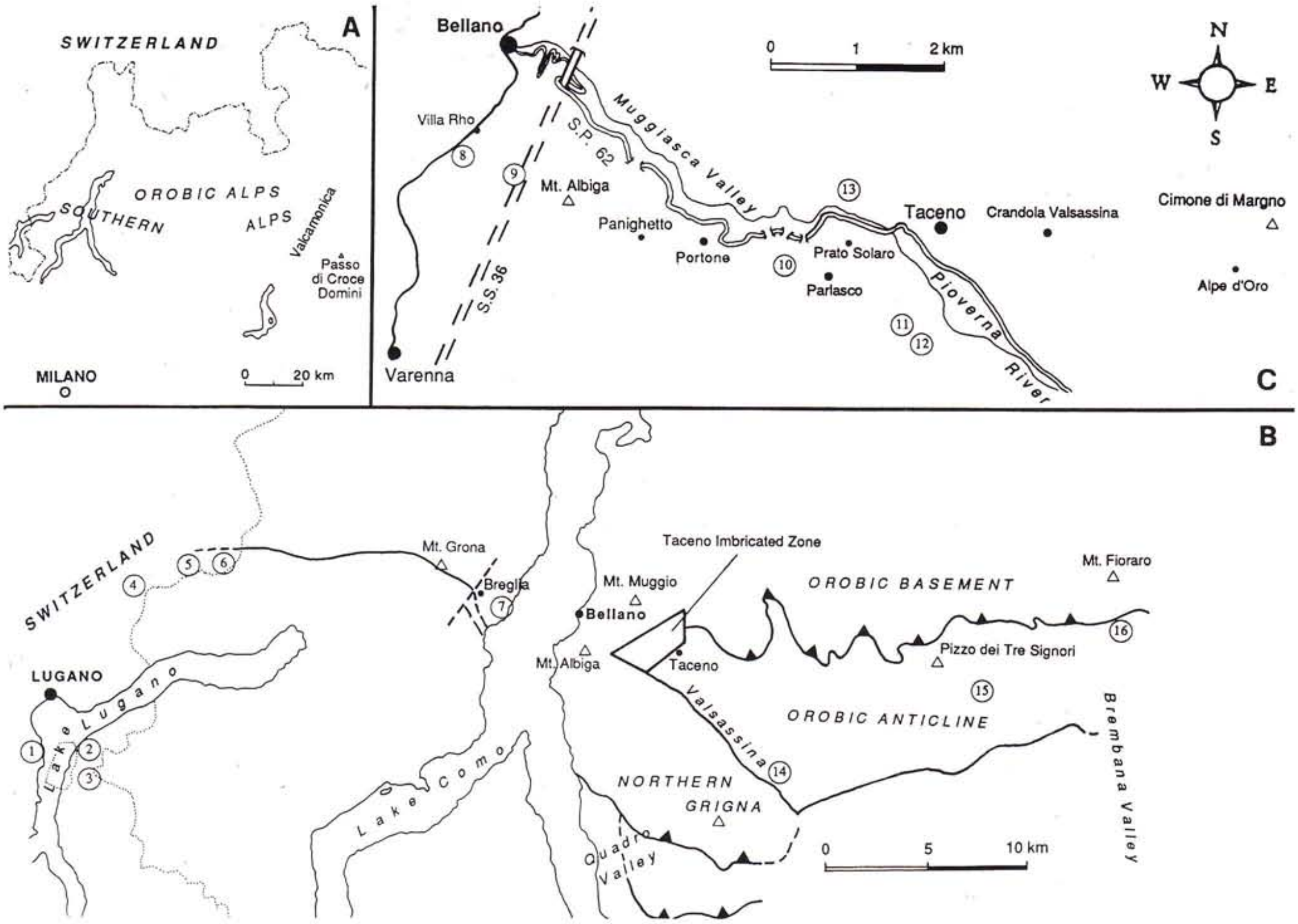

Fig. 1 - Location map. A) Simplified sketch of central Lombardy; B) tectonic map of the studied area (modified after Gianotti & Perotti, 1987); C) inset showing in detail the Taceno area. Sampled sections are numbered (1=Capo S. Martino; 2=Campione d'Italia; 3=Cornaredo; 4=Alpe Scirona; 5=Pairolo; 6=S. Bernardo; 7=Acquaseria-La Gaeta; 8=Bellano; 9=S.S. 36 gallery "Regoledo"; 10=Calchera Valley; 11=Chiaro Valley; 12=Crotti Valley; 13=Comasira; 14=Cügnoletta Valley; 15=Inferno Valley; 16=Ca' S. Marco).

sement and the Northern Grigna thrust sheet (Laubscher, 1985) along the structurally complex Taceno imbricated zone (Schönborn & Laubscher, 1987; Dallagiovanna et al., 1987). The Northern Grigna succession correlates on both shores of Lake Como, whereas a possibly ancestral fault zone at Breglia represents the eastern escarpment of a structural high developed to the west, where the Permo-Triassic terrigenous cover is notably reduced in thickness (Gaetani et al., 1987). Traditionally, the terrigenous succession underlying the Middle Triassic has been subdivided into two formations: Verrucano and Servino (Merla, 1933; De Sitter & De Sitter-Koomans, 1949). More recently another terrigenous unit, the Bellano Formation, was recognized within the Anisian succession (Gaetani, 1982; De Zanche & Farabegoli, 1983; Gaetani et al., 1987). This stratigraphic frame has not been applied to the outcrops west of Lake Como, where Permo-Anisian clastics have been commonly described under the comprehensive informal term "Servino-Verrucano Series" (Lehner, 1952).

Methods of study.

Sandstone samples were mostly collected from measured stratigraphic sections (Fig. 1); 9 were taken from sparse outcrops. Medium- to coarse-grained (1.5 to 0.5 φ), well-sorted unaltered sandstones were preferred. On each of the 184 selected thin sections, stained with red Alizarine, 300 points were counted and compositional parameters were recalculated according to both the QFL Gazzi-Dickinson (Dickinson, 1970; Zuffa, 1985) and QFR (Folk, 1974) methods. Grain size was semi-quantitatively evaluated according to Garzanti (1986).

Obtained detrital modes were grouped empirically in distinct petrofacies which characterize stratigraphically superposed stratal packages, correlatable across most of the investigated area ("petrologic intervals" of Dickinson & Rich, 1972; Tab. 1).

Verrucano Lombardo (Assereto & Casati, 1965).

In the Lake Como area, the Verrucano Lombardo red beds non-conformably overlie the Hercynian base-

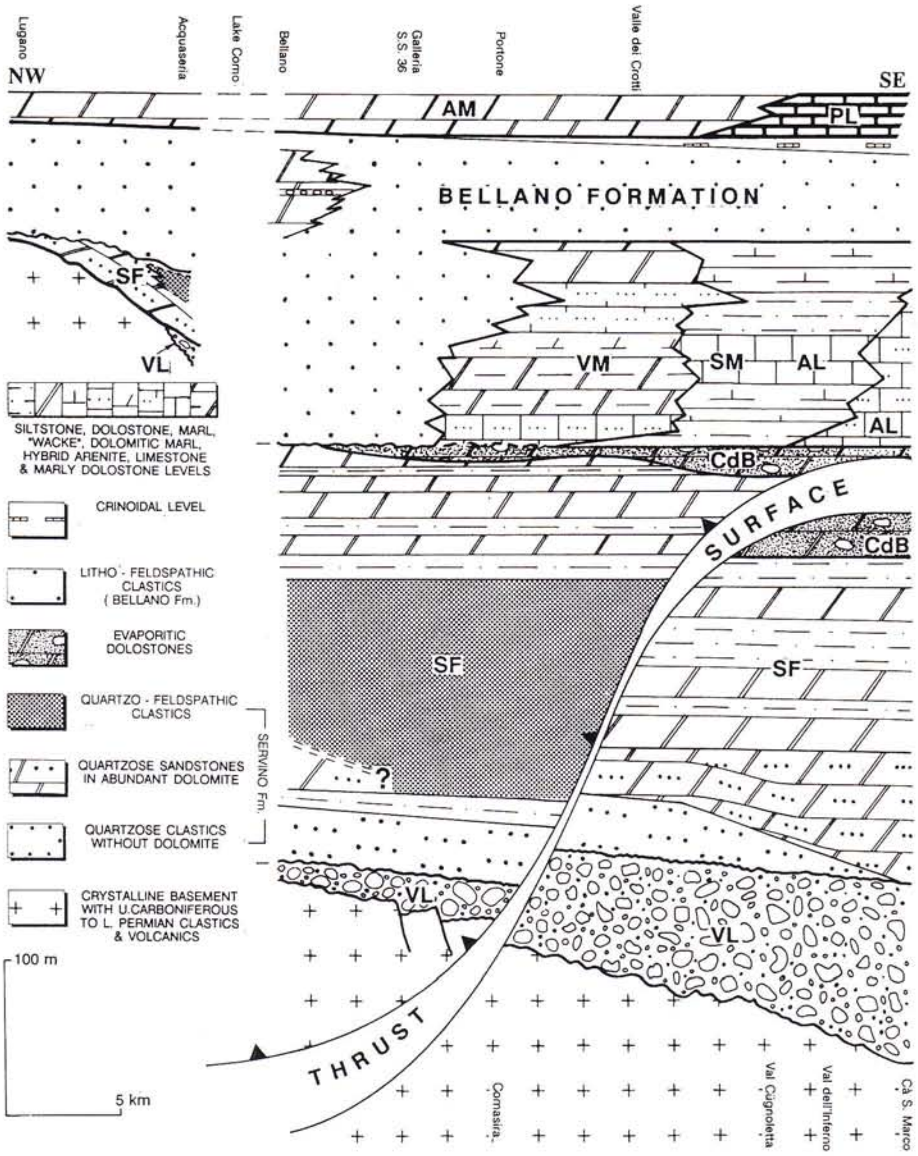

Fig. 2 - Permo-Anisian stratigraphic framework of the studied area. VL = Verrucano Lombardo; SF = Servino Formation; CdB = Carniola di Bovegno; AL = Angolo Limestone (SM = Silty Member); VM = Valsassina Member; AM = Albiga Member of the Esino Formation; PL = Prezzo Limestone. The Northern Grigna thrust separates the Orobic Anticline (below) from the Northern Grigna thrust sheet (above); in the middle-upper part of the Servino Formation, largely fan-delta facies (northwest) are thus thrusted over tidal flat to open platform facies (southeast).

ment, represented by gneisses (Monte Muggio Gneiss sensu Siletto, 1991; Gneiss Chiari; "Gneiss minuti a biotite" Auct.; Fioraro Orthogneiss) and post-Variscan plutons (Val Biandino granodiorite; Val Rossiga and Valle San Biagio granites of De Sitter & De Sitter-Koomans, 1949). In the Pizzo dei Tre Signori area they instead overlie with angular unconformity Upper Westphalian (Jongmans, 1960) to Lower Permian clastics and volcaniclastics, mostly deposited in intramontane basins ("Conglomerato Basale" Auct.; Collio Formation; Ponteranica Conglomerate).

Pebble conglomerates with very few sandstone lenses prevail west of Portone. Sandstones become more abundant in the Orobic Anticline, where the unit is characterized by fining-upward cycles, represented by channellized conglomerates overlain by cross-laminated sandstones and very poorly-sorted siltstones. Wine red colour is due to abundance of both red volcanic clasts and hematite pigment.

Conglomerates are made of subrounded to rounded volcanic pebbles containing hyaline quartz (maximum diameter 13 cm) and subangular to subrounded quartz pebbles (up to 20 cm); rare angular cobbles of Gneiss Chiari are observed between Bellano and Taceno.

Strong increase in thickness from Acquaseria (3 m) to the Valsassina (120÷350 m) and Brembana (150 to 250 m) Valleys, along with sedimentological features, testify southeastward transition from alluvial fan to braid-plain environments (upstream facies of Ori, 1988). The available paleocurrent data on tabular to trough and ripple cross-lamination suggest provenance from both NNW (Ca' S. Marco) and SSW (Inferno Valley). Similar unexpected northward directions were recorded in the Verrucano of the Valcamonica area (Ori et al., 1988).

Age. The unit is unfossiliferous. Since the underlying Collio Formation yielded an Early Permian flora (*Walchia* sp.), and its boundary with the Verrucano Lombardo is marked by an angular unconformity in Val Varrone (Casati & Gnaccolini, 1967, tav. 3), a Late Permian age may be assigned to the Verrucano Lombardo.

Sandstone petrography. Sandstone samples are mostly coarse-grained (range is from fine to very coarse-grained), moderately to poorly-sorted volcanic arenites (Folk, 1974). Two petrofacies have been distinguished (Fig. 3): a lithic lower one (P1; see Fig. 4a and Tab. 2) and a quartzo-lithic upper one, generally characterizing the upper 15 to 30 m of the unit (P2; see Fig. 4c and Tab. 2).

Polycrystalline quartz increases from petrofacies P1 to P2; embayed quartz grains of volcanic origin are common, especially in petrofacies P1 (Fig. 4b). Feldspars are represented by perthitic orthoclase, microcline, chessboard albite and both twinned and untwinned plagioclase. Lithic grains mostly comprise felsitic to vitric volcanic fragments and subordinate granitoid, hypabyssal and metamorphic particles. Very rare terrigenous rock fragments containing quartz grains with quartz overgrowths (mean grain size about 3.5 Φ), white mica flakes, tiny zircons, and authigenic limonite and hematite, are observed at the base of petrologic interval P2 in the Inferno Valley section (Fig. 4d); these show a close resemblance with the "Conglomerato Basale" Auct. sandstones (Casati & Gnaccolini, 1967, p. 31; Boriani & Potenza, 1968).

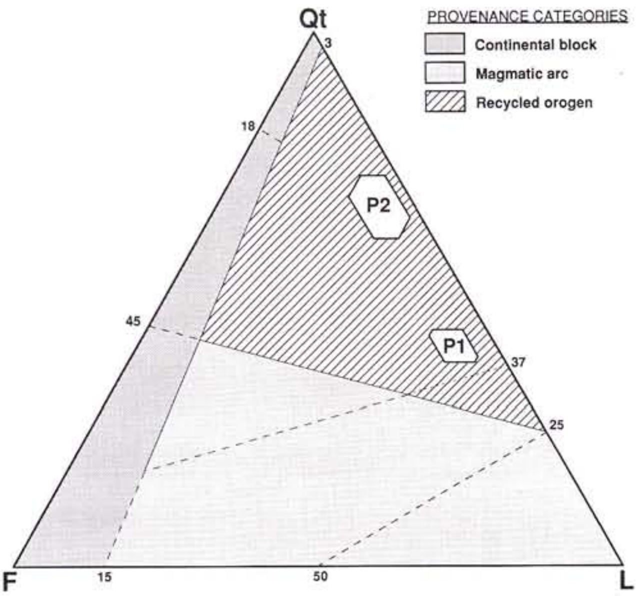

Fig. 3 - Detrital modes (polygons are one standard deviation each side of the mean) for the Verrucano Lombardo (petrofacies P1 and P2). Provenance fields after Dickinson et al. (1983).

Among the heavy minerals, white mica is common; zircon, tourmaline, rutile and apatite also occur. Pseudomatrix (Dickinson, 1970), largely considered of extrabasinal volcanic origin, is widespread; intrabasinal rip-up clasts (Allen, 1962; Garzanti, 1991) are common.

Primary porosity was reduced both chemically by syntaxial quartz cements (5% of rock volume), locally with well-developed meniscus features testifying to vadose origin, and mechanically during burial diagenesis by squeezing of altered volcanic grains. Authigenic hematite (up to 12% of rock volume) is widespread, as well as sericite epimatrix. Abundant dolomite occurs only a few centimetres below the sharp upper boundary with the Servino Formation at Ca' S. Marco (10% of rock volume) and at the very base of the Inferno Valley section (up to 15% of rock volume).

Servino Formation (Brocchi, 1808; Assereto & Casati, 1965; Gaetani et al., 1987).

The Servino Formation rests paraconformably on the Verrucano Lombardo. Total thickness is up to over 300 m in the Bellano area, whereas west of Acquaseria the unit is reduced to discontinuous lenses; a thickness of 150÷200 m can be estimated east of the Valsassina, where stratigraphic sections are invariably truncated by faulting in their upper part. Both facies and compositional data discriminate the basal Prato Solaro Member from the overlying middle-upper part of the formation.

Prato Solaro Member.

The lithostratigraphic name "Prato Solaro Member" is here formally introduced to replace the informal names "quarzite" (Merla, 1933), "Quarziti dell'Alpe d'Oro" (Gaetani et al., 1987), "Membro delle quarziti dell'Alpe d'Oro" (Dallagiovanna et al., 1987), "Quartzite (Verrucano-Servino transition)" (Schönborn & Laubscher, 1987). Introduction of a new formal lithostratigraphic name is necessary since the term "quartzite" is improper for sedimentary rocks, and at Alpe d'Oro (Crandola Valsassina) this unit is exposed with limited thickness and tectonized. The Member represents the basal part of the Servino Formation between Bellano and the Inferno Valley. It consists of reddish and moderately to poorly-sorted granule to pebble imbricate conglomerates, passing upwards to coarse-grained sandstones with reddish rip-up clasts, cyclically intercalated in the Muggiasca Valley with white medium- and coarse-grained, moderately to well-sorted sandstones with wave-ripples and bimodal cross- lamination. At Ca' S.Marco, the member is lacking and the middle-upper part of the Servino Formation directly onlaps at low angle onto the Verrucano Lombardo. The type section, 33.5 m thick and complete from base to top, crops out along the S.P. 62 roadcut, just west and below the Prato Solaro hamlet (Parlasco; Fig. 5b). Here the unit paraconformably rests on the Verrucano Lombardo and it is conformably overlain by the silty lower lithozone of the Servino Formation (Gaetani, 1982).

Type section. Coordinates of the base of the Prato Solaro section in the Gauss-Boaga reference system are 1 526 685E, 5 096 630N. Levels are described base to top (see also Fig. 5a).

- Verrucano Lombardo.

1) Reddish pebble conglomerates and very coarse-grained pebbly sandstones; white quartzite pebbles reach up to 9 cm in diameter and are more common than red wine volcanic pebbles up to 8 cm in diameter. Sparse metamorphic pebbles (mostly from orthogneisses similar to the Gneiss Chiari; Fig. 5c) up to 4 cm are also found. Pebbles are remarkably more rounded than in the underlying Verrucano Lombardo. Two fining-upward cycles, the second with scoured base, start at 0.6 m and 1.8 m above the base (2.60 m).

2) Pink microconglomerates with well-sorted and rounded clasts up to 0.8 cm in diameter (0.10 m).

3) Pinkish, medium to coarse-grained sandstones with sparse pebbles up to 0.9 cm in diameter (1.40 m).

4) Lenticular bed of pink microconglomerates with rounded quartzite clasts (0.25 m).

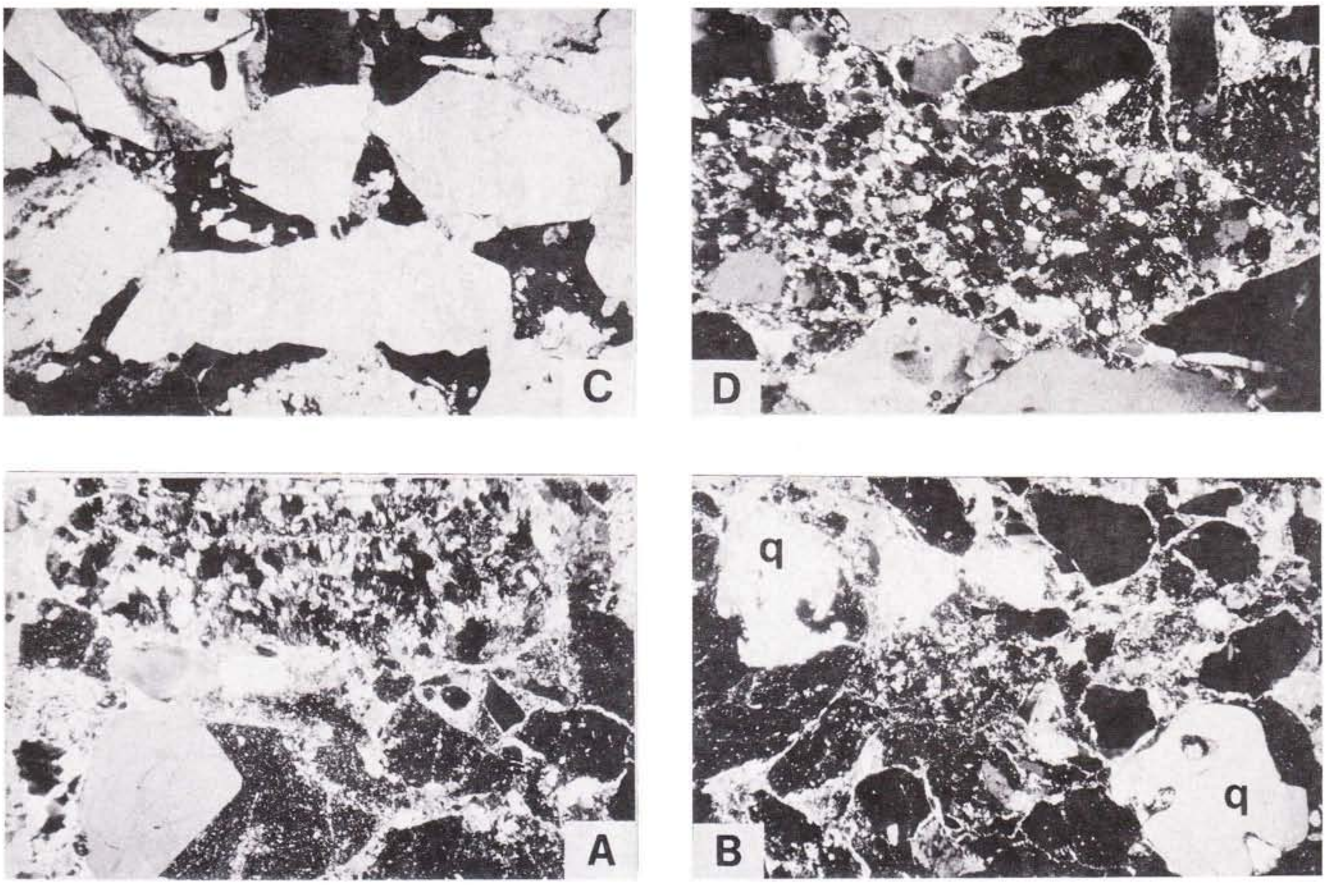

Fig. 4 - Mineralogical composition of the Verrucano Lombardo. a) Volcanic arenite rich in rhyodacitic detritus (17x, 2N; MAX 25; petrofacies P1); b) embayed quartz (q) within rhyolitic rock fragments (23x, 2N; MAX 25; P1); c) quartzose volcanic arenite with interstitial hematite (28.5x, 1N; DS 1; P2); d) quartzarenitic "aporphyric" rock fragment (77x, 2N; MAX 27; P2).

5) Whitish coarse-grained sandstones and pebbly sandstones (1.70 m).

6) Fining-upward bed of pink, coarse-grained sandstones with sparse pebbles (0.60 m).

7) White coarse-grained sandstones with high-angle cross-lamination (1.65 m).

8) Reddish microconglomerates and very coarse-grained, pebbly sandstones (0.40 m).

9) White-pinkish fine conglomerates, supported by a very coarse-grained sandy matrix. White quartzite pebbles reach up to 3 cm in diameter, red volcanic pebbles are by far subordinate. Both pebbles and sand grains are subrounded to rounded (1.20 m).

10) Fining-upward red conglomerates, supported by a very coarse-grained sandy matrix and containing subrounded quartzite pebbles up to 13 cm in diameter (1.30 m).

11) Red, sand-supported conglomerates with slightly scoured base and subrounded quartzite pebbles up to 8 cm in diameter (0.35 m).

12) White-pinkish microconglomerates (0.40 m).

13) Reddish very coarse-grained sandstones, fining-upwards and passing to medium-grained, micaceous sandstones (1.20 m).

14) Framework-supported microconglomerates passing upwards to white-pinkish, very coarse-grained sandstones with well-sorted and rounded grains (0.40 m).

15) Red, fine- to medium-grained micaceous sandstones (1.00 m).

16) Reddish, very-coarse grained sandstones fining-upwards to medium-grained micaceous sandstones alternate with whitish, coarse- to very coarse-grained quartzose sandstones with well-sorted and rounded grains. Reddish beds average ≈ 0.2 m in thickness, whitish beds ≈ 0.8 m (3.15 m).

17) White-pinkish, coarse-grained sandstones with sparse pebbles up to 1 cm in diameter. Parallel to cross-lamination is poorly preserved (2.80 m).

18) Red CU-FU layer of fine- to medium-grained micaceous sandstones, with sand-supported conglomerates containing pebbles up to 5 cm in size in the middle part (1.80 m).

19) Whitish sand-supported conglomerates with pebbles up to 8 cm in diameter and coarse-grained, quartzose sandstones with poorly preserved cross-lamination (1.20 m).

20) Red fine-grained sandstones (0.10 m).

21) White-pinkish sand-supported conglomerates and very coarse-grained sandstones with rounded quartzite pebbles up to 2 cm in diameter (2.80 m).

22) Red, fine- to medium-grained micaceous sandstones (1.20 m).

23) Yellowish, coarse- to very coarse-grained quartzose sandstones with dolomite matrix (5.00 m).

24) Same as 23) but out of reach because of a stream channel (1.00 m).

- Middle part of the Servino Formation.

Thickness is not measurable at Bellano, where the unit is exposed along the lake shore underneath Villa Rho, due to extremely limited outcrops; it reaches a maximum of 50 m between the S.S. 36 gallery "Regoledo" (Gaetani, 1982) and Comasira, whereas it is reduced to about one meter in the Cügnoletta Valley. In the Inferno Valley, lenticular white quartzose conglomerates are

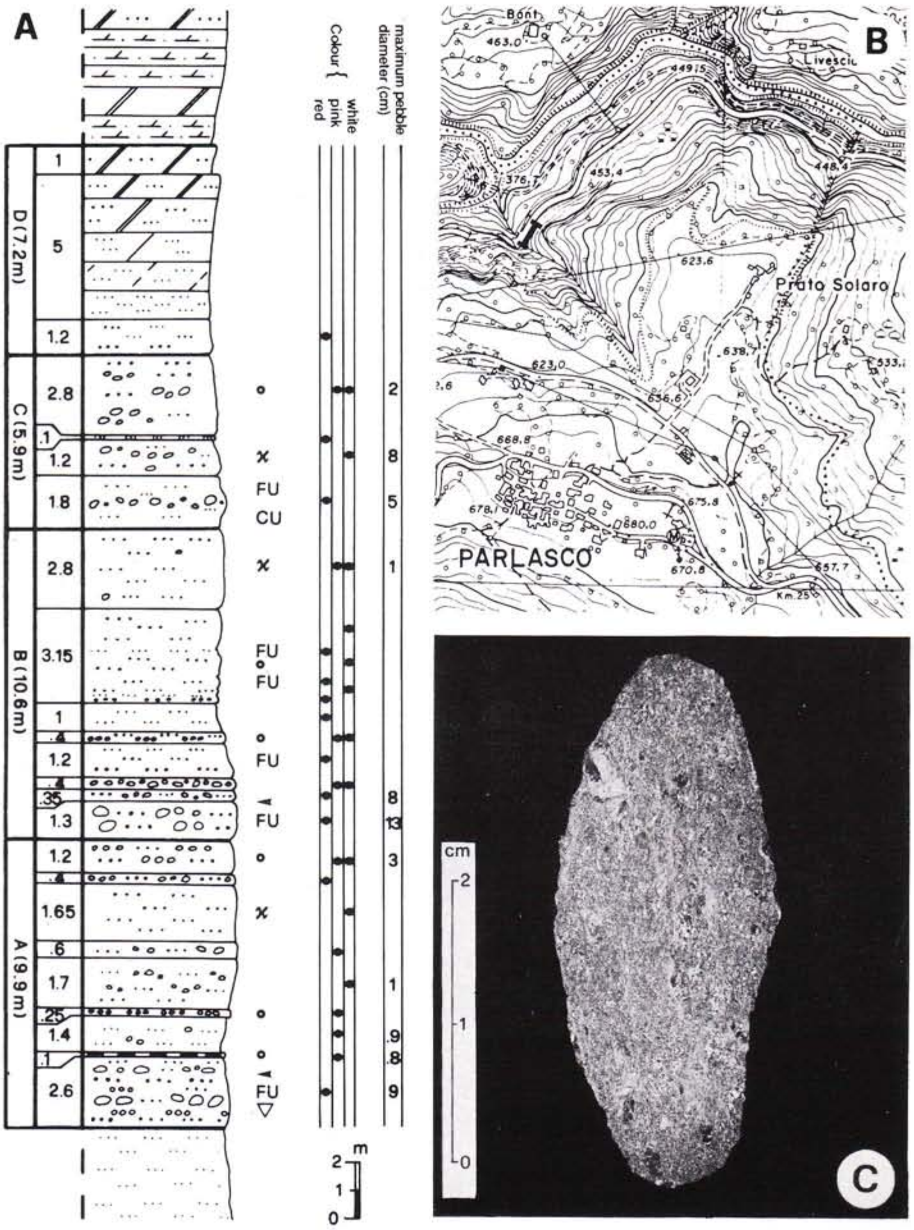

Fig. 5 - Type section of the Prato Solaro Member. a) Stratigraphic column: cyclothems A to D are displayed, as well as sedimentological and lithological features (FU = fining-upwards and CU = coarsening-upwards sequences; triangle = metamorphic pebbles; arrows = scoured bases; tiny circles = rounded grains; χ = cross-lamination; lithological symbols as in Fig. 10); b) location of the section on the 1:10000 Carta Tecnica Regionale; c) platy pebble of Gneiss Chiari from level 1 (2.4x, 2N; DS 184).

0.5 to 1.2 m-thick; locally, strongly quartzose conglomerates in Verrucano facies, belonging to Petrofacies S1 and for this reason tentatively ascribed to the Prato Solaro Member, can be as thick as 7.8 m. For this lens-shaped member, absent west of Lake Como and at Ca' S. Marco, a fan-delta setting is indicated, with coarse alluvial facies passing laterally to high-energy coastal environments influenced by both tides and waves. Tabular to trough cross-lamination and straight-crested wave ripples at Comasira indicate mainly eastward paleocurrents, with the coastline directed about NE/SW. Up to very coarse-grained sandstones of very similar facies and mineralogy, which may be ascribed to the Prato Solaro Member, occur at the base of the Servino Formation also in the Brescian Prealps (Val Camonica area; Marzi, 1995).

Age. Stratigraphic position and the Triassic bivalves *Neoschizodus laevigatus* and *Unionites canalensis*, found by Merla (1933) in strata interfingering with the base of the Servino Formation, indicate an early to mid-Griesbachian age.

Sandstone petrography. The Prato Solaro Member sublitharenitic petrofacies (S1; Fig. 6) consists of poorly to well-sorted, medium to very coarse-grained (sorting vs. grain size: r = 0.83, significance level < 0.1%) volcanic sublitharenites, subarkoses and subordinate quartz-rich feldspathic litharenites and litharenites (Fig. 7a; Tab. 2). Quartz is mainly monocrystalline (C/Q between 0.27 and 0.64). Alkali feldspars, represented by commonly perthitic orthoclase, fresh microcline and chessboard albite, prevail over largely untwinned plagioclase. Lithic grains are mostly volcanic in origin, but also granitoid, hypabyssal, gneissic and phyllitic fragments are common (Fig. 7b); metamorphic pebbles (identified as Gneiss Chiari in the Prato Solaro and Comasira sections; Fig. 5c) occur at the very base of the member. Rare terrigenous rock fragments, identical to those found at the base of petrofacies P2, are observed at the very base of the member in the Comasira section. Accessory minerals are represented by white micas, common even in coarse-grained samples, and by tourmaline, rutile and zircon, at places concentrated in laminae.

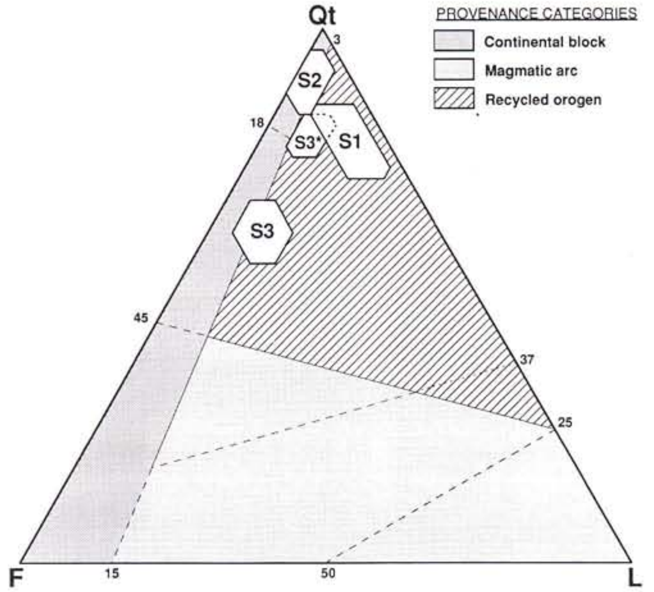

Fig. 6 - Detrital modes (polygons are one standard deviation each side of the mean) for the Servino Formation (petrofacies S1 to S3).

Pores are invariably filled by quartzose, and very subordinate feldspathic, syntaxial cement (9% of rock volume); volcanic pseudomatrix is observed in variable amounts. Sericite and chlorite epimatrix is common (9% of rock volume); carbonates are absent.

Middle-upper part of the Servino Formation.

West of Portone, the 10÷15 m-thick greenish and reddish siltstones overlying the Prato Solaro Member pass upwards to up to 150 m-thick sandstones with interbedded siltstones, yellow dolomitic layers and pebbly sandstones. Channellized fine paraconglomerates with quartzose angular pebbles up to 4 cm in diameter are observed from Alpe Scirona to Bellano, and are traced eastward as far as the Cügnoletta Valley. The unit is sealed by about 100 m-thick yellow dolomites and greenish to reddish intercalated siltstones, yielding the foraminifer *Meandrospira pusilla* (Gaetani, 1982). This succession, reaching a maximum thickness of about 280 m in the S:S. 36 gallery "Regoledo" (Gaetani, 1982), was largely deposited in fan-delta passing upward to prodelta and marginal marine environments.

Thickness strongly decreases west of Lake Como, where siltstones and dolostones are lacking; sandstones are only 46 m thick at Acquaseria and much thinner and discontinuous further to the west.

Between Portone and Ca' S. Marco, the Prato Solaro Member is overlain by up to 65 m-thick, medium- to thick-bedded quartzose sandstones rich in authigenic dolomite, cyclically interbedded with micaceous siltstones and silty dolostones. Flaser to linsen-bedding, wave ripples or bioturbation are widespread; layers rich in Pectinacea locally occur in the first metres above the base. At the top of this sandstone-rich middle lithozone, thin red shaley horizons are typically scoured by a 2 to 3 m-thick sandstone bar with herringbone cross-lamination, in turn overlain by an about 5 m-thick interval of thin- to medium-bedded sandstones. The following upper lithozone (over 100 m-thick at Ca' S.Marco) consists of sparsely bioclastic yellowish carbonates (prevailing in the lower 40 m) and locally fossiliferous green to reddish carbonatic pelites. This succession documents upward transition from tidal sand flat to prodelta and open shelf environments. Paleocurrents are polymodal, with mainly SSE-ward directions (Comasira; Ca' S. Marco); both NNE-ward and SW-ward directions were recorded in the Inferno Valley, where straight-crested wave-ripples hint that the coastline ran indicatively WNW-ESE.

Age. The Servino Formation represents the Lower Triassic, with its base generally believed to mark a hiatus (Assereto et al., 1973). *Claraia intermedia* (Bittner) (determination by R. Posenato, 1995) was recently found in medium-grained sandstones 7 m above the boundary with the Prato Solaro Member in the Cügnoletta Valley section. This pelecypod, belonging to the *C. stachei* group (R. Posenato, pers. comm. 1995), allows correlation with the uppermost Griesbachian- lower Dienerian part of the Siusi Member of the Werfen Formation (Broglio Loriga et al., 1983, p. 559). Occurrence of the ammonoids *Dinarites* and *Tirolites* and of the foraminifers *Meandrospira pusilla*, *Glomospira* and *Glomospirella* indicates an early to late Spathian age for the upper lithozone. The arenaceous middle part of the Servino Fm. of the western Orobic Alps is thus ascribed to the latest Griesbachian-Smithian.

Sandstone petrography. Two petrofacies can be recognized within the middle-upper part of the Servino Formation (Fig. 6). Subarkoses with authigenic dolomite (Fig. 7c) characterize the sandstone-rich middle lithozone of the unit in the Orobic Anticline, and are found at the base of the Servino Formation also west of Lake Como (petrofacies S2); they could not be documented only between Bellano and Portone due to lack of samples in a 60 m-thick interval comprised between petrofacies S1 and S3 in the S.S. 36 "Regoledo" gallery section and to faulting and poor exposures along the lake shore at Bellano.

Arkoses instead represent most of the up to 150 m thick arenaceous body in the environs of Lake Como, between Portone and Acquaseria (petrofacies S3; Fig. 7e).

Subarkosic petrofacies (S2). Moderately to well-sorted subarkoses, with subordinate quartzarenites and sublitharenites, are up to coarse-grained east of Lake Como and up to very coarse-grained to the west (Tab. 2). Quartz grains are mainly monocrystalline (C/Q reaching 0.58 in coarse-grained sandstones), commonly well-rounded and with undulose extinction or Böhm lamellae. Feldspars are mainly represented by orthoclase, altered only in the Inferno Valley and Comasira sections; chessboard albite and microcline are also widespread. Plagioclase grains are subordinate. Feldspars are absent in the Cügnoletta Valley section. Rock fragments are mostly of volcanic origin with felsitic and vitric textures, but also granitoid, hypabyssal and metamorphic (locally containing quartz-tourmaline-apatite assemblages) lithic grains occur. White micas are widespread; tourmaline and zircon, at places concentrated in laminae, are subordinate. Dolomite patches are abundant; "ghosts" of bioclasts (echinoid plates, bivalves, ostracods:

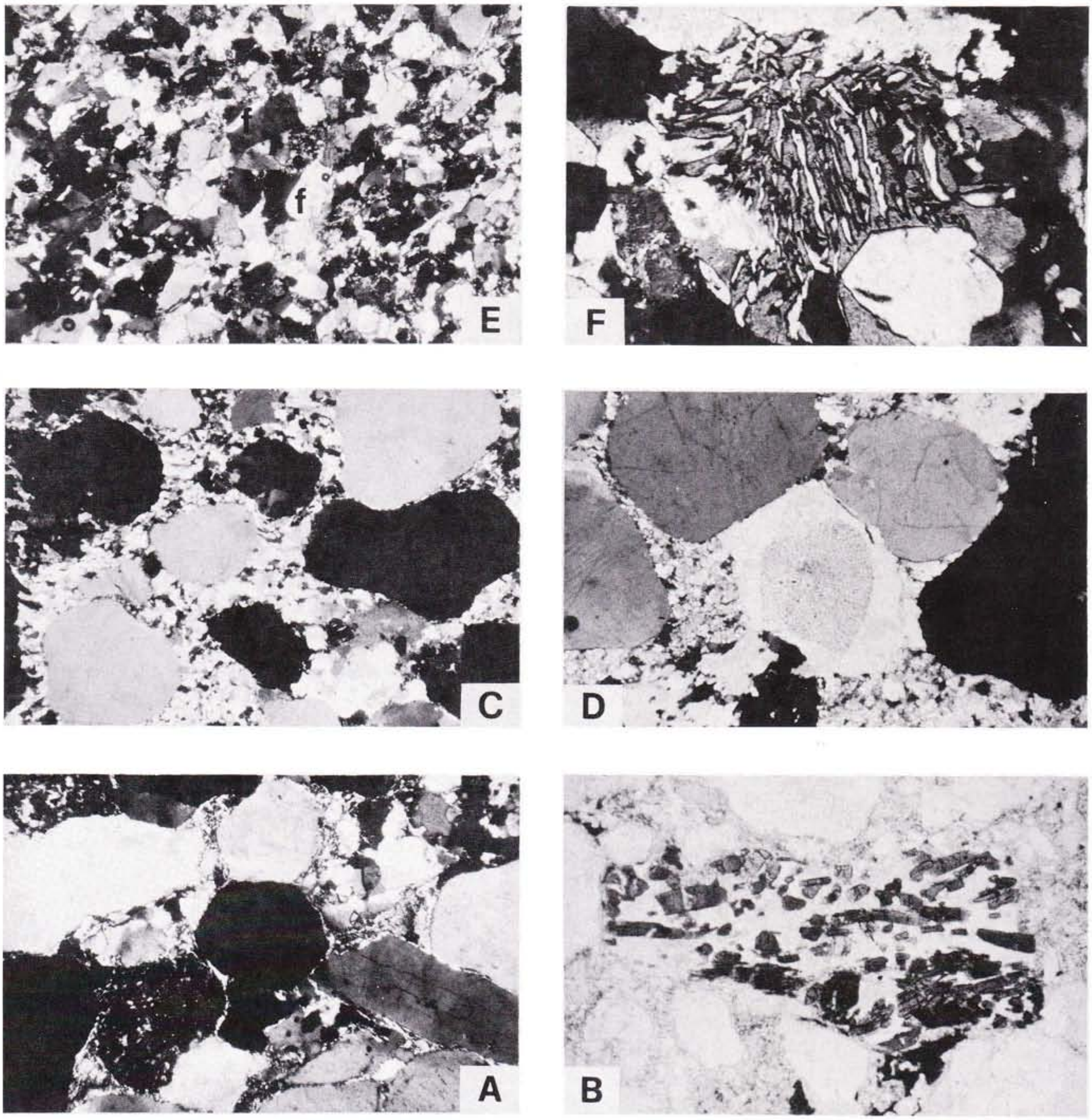

Fig. 7 - Mineralogical composition of the Servino Formation. a) Prato Solaro Member sublitharenite with rounded quartz grains (71x, 2N; DS 60; S1); b) tourmalinite rock fragment (77x, 1N; MAX 30; S1); c) middle Servino quartzarenite with abundant interstitial authigenic dolomite (28.5x, 2N; DS 19; S2); d) dolomitized echinoderm plate with syntaxial cement (77x, 2N; MAX 36; S2); e) Upper Servino fine-grained arkose rich in subangular feldspar grains (f) (28.5x, 2N; DS 140; S3); f) granophyre rock fragment in arkose (71x, 2N; G 1495; S3).

Fig. 7d) or other allochems (up to 8% of rock volume) were recognized in all sections but at Comasira. Mineralizations are present in the Inferno (copper and barium) and Cügnoletta (barium) valleys.

Quartz and subordinate feldspar overgrowths or authigenic fibrous chalcedony make up less than 9% of rock volume. Widespread authigenic carbonates (24% of rock volume on the average) commonly replace detrital grains.

Arkosic petrofacies (S3). Very fine to coarse-grained, moderately to poorly-sorted arkoses and lithic arkoses (Tab. 2). Quartz grains are mainly monocrystalline, but also commonly show composite extinction and sutured intercrystalline boundaries. Feldspars include orthoclase, commonly perthitic or kaolinized, microcline and chessboard albite, prevailing over mostly untwinned plagioclase. Volcanic lithics with felsitic, vitric and rarely microlitic textures predominate, but also granitoid (Fig. 7f), hypabyssal and metapelitic grains, along with rare pseudomatrix, occur. White mica is abundant; tourmaline, zircon and apatite are at places concentrated in laminae. Intrabasinal carbonate grains are absent. Primary pores are filled by syntaxial cement (15% of rock volume, three fourths of which quartzose, one fourth feldspathic); sericite to chlorite epimatrix is also present. Authigenic dolomite, ferroan dolomite, sphene and opaques make up to 25% of rock volume. Authigenic epidote was recorded (DS 108, DS 140).

In the Orobic Alps, subarkoses and subordinate sublitharenites, quartz-rich lithic arkoses and feldspathic litharenites found at the transition between the middle and upper lithozones of the Servino Formation yielded an average composition Q=79.7, F=11.8, L=8.5, closely comparing with samples from the base and top of petrofacies S3 in the Acquaseria section (these samples are indicated as S3* in Fig. 6 and Tab. 1, 2). Identical compositions are recorded in pebbly sandstones in the lower part of the Alpe Scirona section. C/Q ratio is intermediate between those characterizing petrofacies S2 and S3.

"Carniola di Bovegno" (Assereto & Casati, 1965; Gaetani et al., 1987).

The Carniola di Bovegno, up to 50 m-thick but commonly much thinner, comprises marly dolostones and dolomitic quartzose-micaceous wackes with evaporites (Fig. 9a). This unit overlies the Servino Formation with tectonized and poorly exposed contact. A terrigenous sabkha depositional environment, testifying to arid climatic conditions, is interpreted (Casati & Gnaccolini, 1967). The top of the Carniola di Bovegno is generally ascribed to the earliest Anisian (De Zanche & Farabegoli, 1983).

Angolo Limestone (Assereto & Casati, 1965).

The Angolo Limestone, up to 350 m thick in the study area (Gaetani et al., 1987), is mostly represented by limestones to micaceous silty marls. The amount of terrigenous detritus increases northwestward (Silty Member of Gaetani et al., 1987), where up to fine-grained micaceous sandstones occur. The unit, resting conformably on the Carniola di Bovegno and interfingering with the Bellano Formation, was deposited in a subtidal environment.

Age. Stratigraphic position points to an Early-Middle Anisian age (Casati & Gnaccolini, 1967).

Sandstone petrography. The only sample fit for modal analysis collected in the Silty Member (DS 55) is a poorly-sorted, fine-grained lithic arkose (Tab. 2) rich in white mica flakes.

Bellano Formation and Valsassina Member (Gaetani, 1982; De Zanche & Farabegoli, 1983; Gaetani et al., 1987).

The Bellano Formation is an up to 210 m-thick, mostly terrigenous prism, cropping out between Lake Lugano and the Quadro Valley (Grigna Group; Gaetani et al., 1987), which overlies the Servino Formation (Lake Como), the Carniola di Bovegno (M. Albiga area) or the Angolo Limestone (Valsassina). This lower boundary is disconformable to paraconformable, and marks a hiatus in the Lake Como area, where the upper silty-dolomitic lithozone of the Servino Formation is lacking (Acquaseria) or slightly scoured (Bellano). East of M. Albiga, the unit is represented by the Valsassina Member, overlying paraconformably the Servino Formation near Portone, and conformably the Silty Member of the Angolo Limestone to the east (Chiaro Valley and Crotti Valley sections). Due to high lateral variability, the Bellano Formation is best described by considering its most representative sections, that are presented below, west to east.

Lake Lugano area. The unit consists of conglomeratic red beds at Capo S. Martino. At Campione d'Italia, channelized braided stream fining-upward sequences are overlain by coarsening-upward sequences capped by carbonaceous mudrocks, ascribed to progradation of pebbly sandstone deltaic mouth bars. The upper part of the section is represented by mainly distributary channel conglomeratic deposits. Paleocurrents suggest that this fluvial-dominated fan-delta prograded over restricted seas and lagoons towards the north-east. Climate changed from semiarid in the lower part, where "flash floods" are common, to semi-humid in the middle part, characterized by carbonaceous topset layers deposited in coastal swamps.

Acquaseria. The Bellano Formation (about 60 m thick) consists of sandstones and conglomerates in channelized bodies containing mostly angular quartz pebbles, volcanic pebbles and silty mudclasts (found at the base and referred to the underlying Servino Fm.). Siltstone interbeds are common, whereas carbonates are subordinate and present only at the top.

Bellano (thickness about 210 m). Channelized conglomerates and sandstones pass upwards to monotonously interbedded sandstones and siltstones, followed in turn by thick marly dolostones and sealed by prograding red beds, locally with imbricated pebbles up to 10 cm in size, indicating mainly eastward (but also westward, suggesting action of significant flood tides) paleocurrent directions.

S.S. 36 gallery "Regoledo". Thickness decreases to 130 m (Gaetani, 1982). The upper marly dolostone interval is absent; red beds are 20 to 30 m-thick.

Muggiasca Valley. Near Case Panighetto (Perledo), the lower-middle part of the Bellano Formation is replaced by the Valsassina Member, whereas its upper part, consisting of red beds at Acquaseria and Bellano, is represented by coarse-grained sandstones with concretions and abundant interstitial dolomite locally showing "ghosts" of echinoids, foraminifers and ostracods (thickness between 60 and 80 m in the Calchera to Crotti valleys). From Portone to the Calchera Valley, an up to 10 m-thick pebbly sandstone interval directly overlies the crinoid-rich horizon which marks, further to the east, the base of the Albiga Member of the Esino Formation. The topmost Bellano Formation clastics west of the Chiaro Valley are thus lateral equivalent in part to the Illyrian Albiga dolomites and Prezzo limestones.

The Valsassina Member increases in thickness eastward from the Calchera (45 m) to the Chiaro and Crotti valleys (about 130 m). It consists of carbonatic "wackes" followed by vuggy dolostones and rippled hybrid carbonates, by fine to medium-grained sandstones and finally by dolomites overlain by the main terrigenous body of the Bellano Formation.

The Bellano Formation and Valsassina Member are interpreted as a prograding fan-delta, interfingering towards the south-east with prodelta to lagoonal deposits (Gaetani et al., 1987).

Age. Foraminiferal assemblages indicate an Anisian age (Rossi, 1986). According to stratigraphic position, a largely Bythinian-Pelsonian age, up to Illyrian west of Chiaro Valley, is suggested.

Sandstone petrography. Three petrofacies can be recognized (Fig. 8). Petrofacies A1 characterizes the Silty Member of the Angolo Limestone and the lower-middle part of the Bellano Formation, including the Valsassina Member; petrofacies A2 characterizes stratigraphically higher layers in the Bellano Formation; petrofacies A3 characterizes the top of the Bellano Formation and the Albiga Member of the Esino Formation.

Litho-feldspathic lower petrofacies (A1). Medium to very coarse-grained (most samples in the 1.5÷0.5 φ range), poorly to moderately-sorted lithic arkoses and feldspathic litharenites (Tab. 2). Quartz is both monocrystalline and polycrystalline; embayed quartz grains of volcanic origin never exceed 3% of rock volume, and commonly are less than 1%. Sutured intercrystalline boundaries are frequently observed within polycristalline grains. Feldspars are represented by orthoclase, commonly perthitic (DS 45; up to 1.5% of rock volume in DP 14; Fig. 9b), fresh microcline and chessboard albite; plagioclase, mainly untwinned, is subordinate (P/F ranges from 0.04 to 0.63). Lithic grains are mostly volcanic; plutonic, hypabyssal (some with well-preserved granophiric or micrographic textures) and metamorphic rock fragments also occur; terrigenous lithic grains are very rare. White mica is widespread (2% of rock volume) and by far more abundant than biotite. Also commonly zoned tourmaline, zircon and apatite - at places concentrated in laminae - are frequently observed. Recrystallized carbonatic patches with "ghosts" of echinoid plates, recognized in some samples (DS 49), are mostly interpreted as coeval intrabasinal grains. Primary pores were filled by pseudomatrix (largely of volcanic origin), chloritic or sericitic epimatrix, and syntaxial quartzose or feldspathic cements. Dolomite, calcite, ferroan carbonates, opaques (pyrite, limonite, hematite) or sphene, grown in secondary pores, make up to 36% of rock volume.

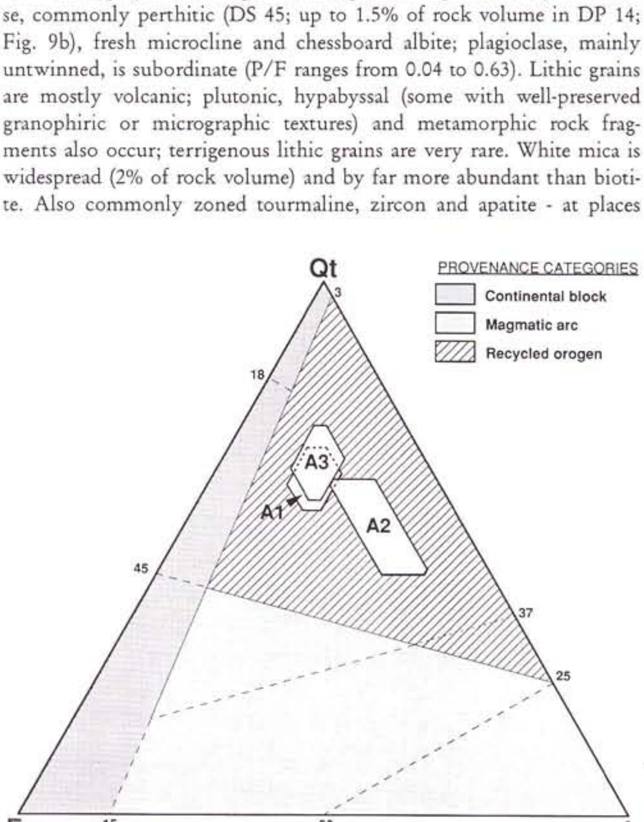

Fig. 8 - Detrital modes (polygons are one standard deviation each side of the mean) for the uppermost Spathian to Anisian clastics (petrofacies A1 to A3).

Lithic-rich interval (A2). Fine to very coarse-grained, very poorly to moderately-sorted feldspathic litharenites, litharenites and lithic arkoses (Tab. 2). Quartz is mainly monocrystalline; embayed quartz of volcanic origin reaches up to 4% (SR 12). Feldspars are mainly represented by commonly perthitic orthoclase and microcline; chessboard albite is rare, plagioclase (twinned and untwinned in roughly equal proportions) is subordinate. Mostly volcanic rock fragments show felsitic, vitric (Fig. 9c, d) and very rarely microlitic textures. Metamorphic, hypabyssal and granitoid rock fragments are also widespread (MRF up to 9% in sample SR 140). White mica and ultrastable heavy minerals make up the whole accessory fraction. Carbonate clasts occur only at Campione and in sample SR 10 (Calchera Valley), where patches of sparry dolomite (25% of rock volume) are largely recognized as echinoid plates. Primary pores were filled both by squeezed lithics, mostly of volcanic origin (pseudomatrix represents 2% of rock volume), and by quartzose or feldspathic overgrowths (9% of rock volume; quartz versus feldspar cement ratio about 7.5). Sericitic to chloritic epimatrix is also abundant (5.5% of rock volume). Secondary pores (15% of rock volume) were filled by authigenic dolomite, calcite, ferroan carbonates and opaques.

Litho-feldspathic upper petrofacies (A3). Fine to coarse-grained, very poorly to moderately-sorted lithic arkoses, and subordinate feldspathic litharenites and subarkoses (Tab. 2). Quartz is monocrystalline and polycrystalline. Orthoclase and microcline prevail over mainly untwinned plagioclase; chessboard albite is absent. Lithic grains are mostly volcanic in origin; also metamorphic (up to 7% of rock volume in SR 13), granitoid and hypabyssal rock fragments were recorded. White mica is widespread and commonly prevails over zircon, tourmaline, rutile and "leached" biotite: in the two fine-grained samples (G 1507 and NR 18), however, heavy minerals are equally or even more abundant than micas. Carbonate clasts are rare.

Primary porosity was reduced by quartz or feldspar overgrowths (11% of rock volume; quartzose versus feldspathic cement ratio ≈ 5), phyllosilicatic epimatrix, and squeezed weaker grains (pseudomatrix 1.8% of rock volume). Secondary pores (13% of rock volume on the average) were filled by authigenic calcite or dolomite (up to 35% of rock volume) and opaques.

Albiga Member (Gianotti, 1968; Gaetani et al., 1987).

The Albiga Member of the Esino Formation, 40 to 70 m thick, comprises grey dolomites and dolomitic limestones (Fig. 9e) cyclically alternating with thin beds of deep red to dark green siltstones and rare up to medium-grained reddish sandstones with parallel lamination. This member overlies the Bellano Formation conformably, with a crinoid-rich horizon (absent West of Portone, up to 12 m-thick at Crotti Valley) marking the boundary east of Calchera Valley and seemingly passing eastward to the "Banco a Brachiopodi". In the upper part of the unit, reddish to yellowish tuffaceous beds are observed along the lake shore at Bellano.

Age. The Albiga Member is dated with foraminifers and dasycladaceans as Illyrian (Gaetani, 1982; Gaetani et al., 1987).

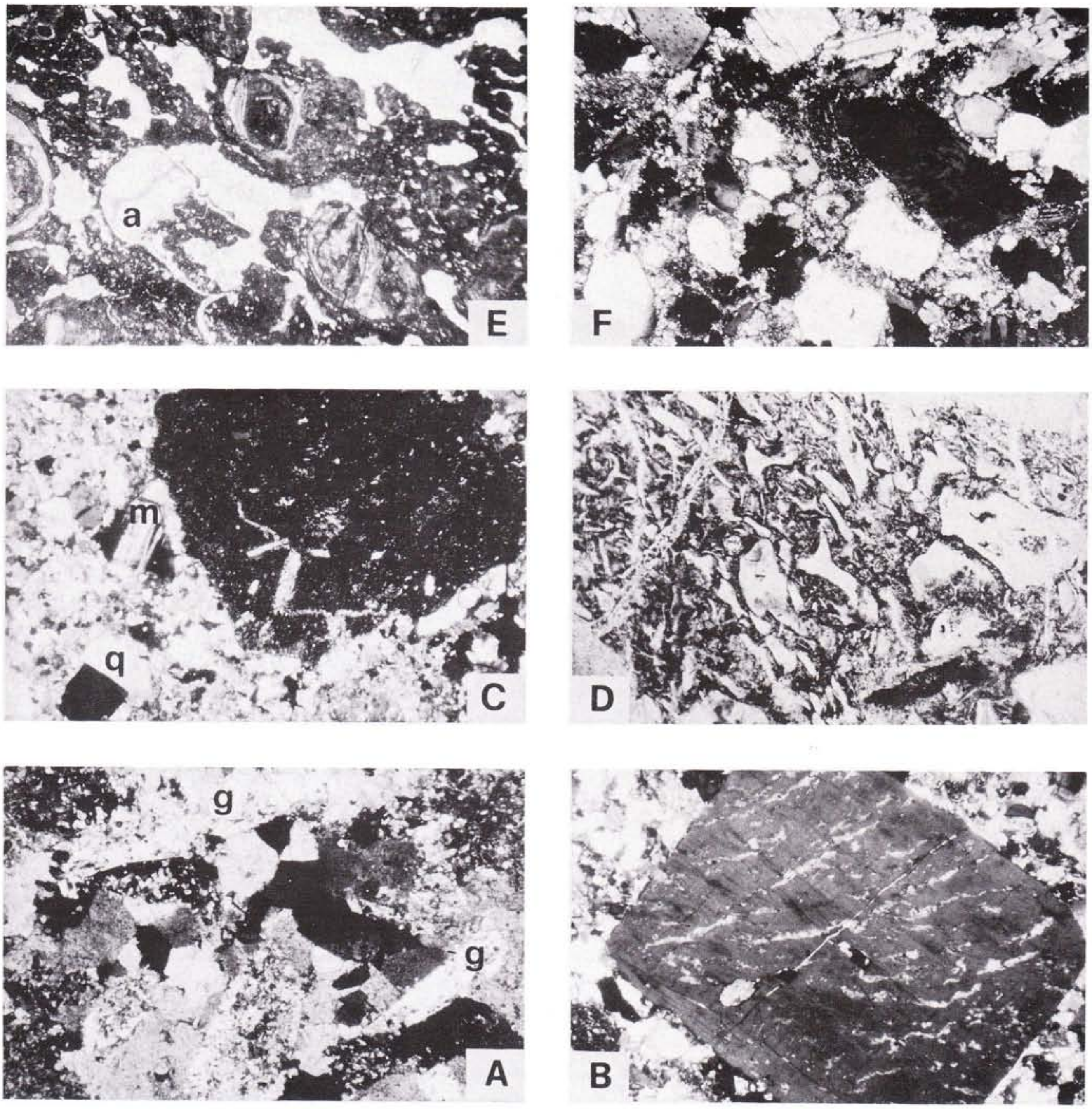

Fig. 9 - Mineralogical composition of the Anisian units. a) Large gypsum crystals (g) with calcite and anhydrite inclusions within a Carniola di Bovegno vuggy dolostone (28.5x, 2N; SR 31); b) angular perthitic K-feldspar (28.5x, 2N; DS 45; A1); c) large vitric volcanic lithic grain, microcline (m) and polycrystalline quartz (q) in a poorly-sorted and dolomitized sandstone from the lithic- rich interval (28.5x, 2N; SR 12; A2); d) glass shards in volcanic rock fragment (77x, 1N; CF 48; A2); e) Albiga Member limestone with oncolites and an ammonoid section (a) (7x, 1N; LD 38); f) Albiga Member medium-grained lithic arkose (71x, 2N; SR 18; A3).

Sandstone petrography. Sample SR 18, the only one fit for modal analysis, is a medium-grained, moderately-sorted lithic arkose (Fig. 9f: see Tab. 2).

Discussion

The eight petrofacies recognized within the Permo-Anisian stratigraphic succession of the Western Southern Alps (Tab. 1) show only little overlap (except for petrofacies A1 and A3; Fig. 8). These petrofacies, documented within rock units that seemingly represent laterally continuous and correlatable sets of strata (Dickinson & Rich, 1972; Fig. 10), are assumed to reflect eight successive stages in the evolution of source areas. Other factors controlling detrital modes, such as climate, relief, depositional environments and diagenesis, proved in fact to have had minor effects and only at specific periods of time (Garzanti et al., 1996).

Petrofacies	n	Q	σ	F	σ	L	σ	C/Q	P/F	V/L
A3	16	66	7	18	5	16	4	.50	.30	.94
A2	23	54	9	14	4	32	12	.34	.19	.91
A1	39	63	6	20	5	17	4	.47	.25	.94
S3	14	62	6	29	5	9	5	.39	.30	.93
S3*	7	80	3	12	5	8	3	.36	.24	.89
S2	46	90	6	7	5	3	3	.28	.30	.92
S1	21	79	7	6	4	15	9	.41	.33	.96
P2	14	67	6	6	4	27	6	.50	.29	.94
P1	4	41	3	7	3	52	5	.38	.23	.97

Tab. 1 - Main petrographical parameters (Dickinson, 1970) characterizing the recognized petrofacies of Permian (P1, P2), Scythian (S1 to S3) and Anisian (A1 to A3) age. S3* = quartz-enriched, feldspar-depleted petrofacies S3 (see text). Number of samples (n) and standard deviation (σ) for each parameter are given. See Tab. 2 for explanation of parameters.

An additional petrofacies characterizes four subarkoses to quartz-rich arkoses collected in the S. Bernardo section, which are the only samples lacking volcanic rock fragments. They were deposited after the Hercynian Orogeny but, with all likelihood, before the emplacement of Lower Permian volcanic rocks; detrital modes thus confirm the Carboniferous age indicated by Lehner (1952).

Verrucano Lombardo. The Verrucano Lombardo was fed by erosion of the Lower Permian ignimbritic plateaux and - subordinately - of the Hercynian basement (petrofacies P1). The abrupt compositional change from lithic petrofacies P1 to quartzo-lithic petrofacies P2, observed in the Inferno Valley section, does not correspond to a facies change, thus recording a provenance signal possibly coupled with a significant hiatus. In fact, at the base of petrofacies P2 (M 27), the first appearance of arenaceous rock fragments (very fine-grained quartzarenites lacking volcanic lithics, similar to those typical of the "Conglomerato Basale"), along with much higher quartz content, suggest wider dissection of the ignimbritic plateaux, with erosion reaching more conspicuously into the underlying Carboniferous siliciclastics and crystalline basement.

Detrital modes of selected samples from the Verrucano Lombardo by Fontana & Zuffa (1982) are consistent with our petrofacies P2 (Valsassina samples) or P1+P2 (Pizzo della Nebbia, Val Sanguigno). Sandstones much richer in feldspar (F > 20) are reported at Passo di Croce Domini; further to the east in the Val Gardena Sandstones (where L is invariably < 35), they become predominant at Butterloch and exclusive from Cadore to Friuli.

At the top of the unit at Ca' S. Marco, within an overall fining-upward megasequence consisting of four distinct FU-cyclothems and documenting gradual transition from proximal to distal braidplain, feldspars slowly but steadily increase (corr. coeff. stratigraphy vs. F = 0.95, sign. lev. < 0.1%). This trend points to progressive local unroofing of granitoid rocks; it is unlikely to have been produced by increasing aridity at the close of the Permian (Holser & Magaritz, 1987), since this feldspar increase was not observed in other sections. Grain size control is minor (corr. coeff. φ vs. F = -0.5, sign. lev. > 10%), and decreasing relief is supposed instead to cause depletion of detrital feldspars (Folk, 1974, p. 85).

Prato Solaro Member. The Prato Solaro Member (sublitharenitic petrofacies S1) was most likely fed by the same source area of the Verrucano Lombardo. Further quartz enrichment points to greater contribution from the crystalline basement and its pre-volcanic siliciclastic cover, lying beneath the dissected Lower Permian plateaux. The basal conglomeratic layer is in fact invariably enriched in both metamorphic (DS 184) and well-rounded quartzose pebbles. Moreover, in the immediately overlying sandstones (DS 60), quartzose arenaceous rock fragments identical to those observed at the base of petrofacies P2 and textural inversions (Folk, 1951) hint to significant recycling of older aporphyric sandstone units.

Reworking in high-energy coastal environments also contributed to greater mineralogical stability, associated with greater textural maturity in white sandstones showing wave ripples and tidal cross-lamination. The relative incidence of source area evolution and depositional environment as factors controlling detrital modes can be tested in the Comasira section. Here the Prato Solaro Member, displaying overall enrichment in quartz from base to top, consists of 4 to 6 m-thick FU cyclothems, each invariably characterized by a regular increase in the quartz/lithic ratio from bottom to top (Fig. 11). These metric cyclothems document rapid progradation of reddish deltaic deposits, followed by white sandstones testifying to transgression and prolonged reworking of detritus in coastal settings. Short-term changes observed within each cyclothem are thus ascribed to environmental processes, whereas the long-term trend is interpreted to reflect evolution of the source. If these assumptions are correct, correlations of compositional parameters versus various facies indexes (Garzanti et al., 1996) indicate that up to 50% of variance in detrital modes can be ascribed to sedimentary processes in this case. Climatic control is unlikely, as there is no evidence of increasing humidity through the considered time span.

Since the boundary between the Verrucano Lombardo and the Prato Solaro Member possibly coincides with the Permian-Triassic boundary, prolonged pedogenesis of detritus within alluvial plain storage areas may have also contributed to greater mineralogical stability. Grain size control proved instead insignificant (correl.

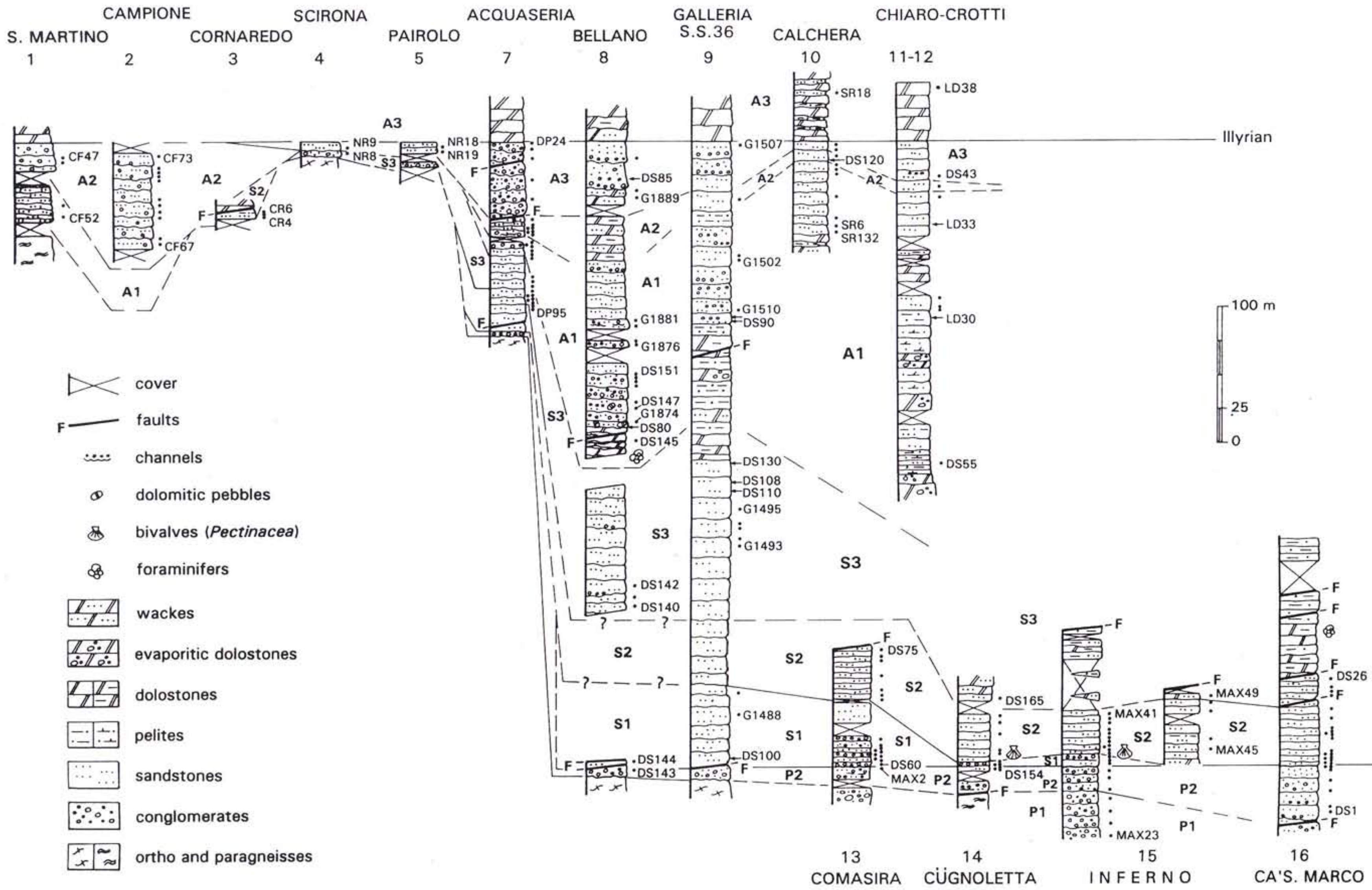

Fig. 10 - Measured stratigraphic columns from S. Martino to Ca' S. Marco. Numbers as in location map (Fig. 1). Datum planes are the inferred Permo-Triassic boundary and the Illyrian transgressive surface. Arrows show approximate stratigraphic position of samples from sparse outcrops.

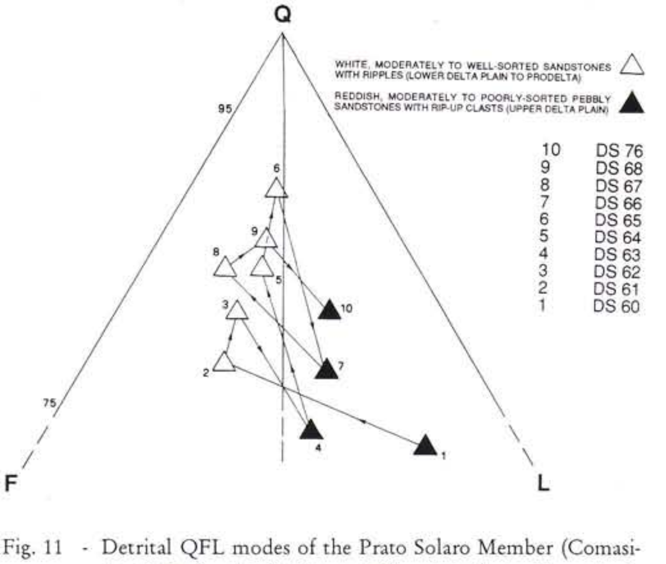

Fig. 11 - Detrital QFL modes of the Prato Solaro Member (Comasira section), displaying overall upward enrichment in quartz and depletion of lithic grains (mostly of volcanic origin). Each of the three high-frequency cyclothems is characterized by quartz enrichment from basal red beds to the overlying white submature/mature sandstones.

coeff. with compositional parameters ≤.35, sign. lev. invariably >10%).

Servino Formation. Subarkosic petrofacies S2 records a further increase in both textural maturity and mineralogical stability in the late Griesbachian. Even though the latter can be ascribed to several concurring factors, including further dissection of source areas, severe reworking in coastal environments, recycling and possibly even diagenetic replacement of unstable grains by authigenic dolomite, this further step into the "craton interior" field of Dickinson et al. (1983) points to the absence of relevant tectonic activity at this stage.

Arkosic petrofacies S3 is recorded in a geographically confined, texturally immature and up to conglomeratic clastic wedge, testifying to abrupt rejuvenation of relief and unroofing of granitoid bodies. There is no evidence in fact for increasing aridity, and fan-delta environments are expected to be characterized by greater abundance of lithic grains rather than feldspars with respect to coastal settings (Mack, 1978; Winn et al., 1984; Garzanti, 1986). Control of grain size on feldspar abundance is weak (correl. coeff. -.56, sign. lev. <5%). Appearance of a few microlitic rock fragments suggests provenance from intermediate volcanic and subvolcanic bodies emplaced either penecontemporaneously or at an earlier stage of the Lower Permian magmatic event (Massari, 1988).

Vertical transition from petrofacies S2 to S3 is best documented at Acquaseria, where 25 m-thick quartzose sandstones and siltstones (S2) are overlain by 20 m-thick quartzo-feldspathic sandstones and channellized microconglomerates (S3). Both at the bottom and top of the latter, sandstones show transitional modes (DP 11, DP 72). From Cügnoletta Valley to the east, the same transitional modes are recorded from about 10 m below to just above the red shale marker horizons found between the lower and the upper lithozones of the Servino Formation. Since the upper lithozone is represented all across the Orobic Alps by mudrocks of early to late Spathian age, the increase in feldspars can be dated at around the Smithian-Spathian boundary.

This major petrographic change can hardly be accounted for by a eustatic change alone, since the latter can produce deepening of subaerial erosion levels of only a few tens of metres, thus insufficient to unroof large volumes of basement rocks.

The great thickness of up to microconglomeratic arkosic petrologic interval S3 between Bellano and Portone is consistent with deposition in fan deltas, fed largely from gneissic to granitoid basement rocks exposed along fault escarpments located west of Acquaseria. Further to the west, petrofacies S3 is seemingly recorded in a few meters of pebbly sandstones at Alpe Scirona and possibly at Pairolo. Tectonic activity at this stage is also recorded in the Recoaro area (Monte Naro Breccia of De Zanche & Farabegoli, 1981).

Bellano Formation. Petrofacies A1 to A3 mark an enrichment in polycrystalline quartz grains and both metamorphic and volcanic lithics. The increase in metamorphic detritus, with still abundant detrital feldspars, is consistent with wider exposures of the crystalline basement. The enrichment in volcanic lithics cannot be ascribed either to sedimentary processes, since environments changed little with respect to the underlying petrologic interval S3, or to recycling of Verrucano clastics (petrofacies A1 would not be less quartzose than P2; Blatt, 1967, fig. 1). Since diagenetic textural changes at almost anchizonal conditions prevent recognition of paleo-volcanic from neo-volcanic origin of volcanic lithics (Zuffa, 1985), we are left with at least two different explanations: a) inversion of Collio-type pull-apart basins and erosion of the Lower Permian volcanic plateaux to the northwest, coupled with tectonically driven changes in the drainage patterns; b) renewed rhyodacitic volcanic activity. In either case, this major change in provenance took place around the Spathian-Anisian boundary, since sandstones at the very top of the Servino Formation already display modes typical of petrofacies A1 (DS 145).

Petrofacies A2 is defined by a peak of volcanic lithic grains. A complete depositional sequence is testified at Campione within the A2 petrologic interval. Both thickness of sandstones rich in volcanic detritus and abundance of the latter are maximum at S. Martino and Campione (L up to 60, thickness = 65 m), whereas they decrease eastward (L up to 33, thickness = 20 m at Acquaseria; L up to 29, thickness = 10 m at Calchera Valley). Further to the east, in the Chiaro Valley, petrofacies A2 is represented only by a minimum of the F/L ratio (DS 44), occurring - as the Calchera Valley peak - 40 m above the top of the Valsassina Member.

Again, environmental control cannot explain this increase of volcanic rock fragments. The lithic-rich petrologic interval (A2) comprises in fact a variety of sedimentary lithofacies, from grey coarse-grained lenticular clastics to evenly-bedded sandstones alternating with siltstones and arenaceous dolostones; but not, as it would be expected (Winn et al., 1984), the overlying fluviatile red beds, already belonging to the more feldspathic petrologic interval A3. Environmental control, however, does explain progressive depletion of lithic grains from fluvio-deltaic settings in the west to coastal and shallow-marine environments in the east (Winn et al., 1984; Garzanti, 1986; Valloni et al., 1993). Petrofacies A2 thus records a dramatic provenance signal, which again may be interpreted either as uplift and erosion of the Lower Permian Lugano ignimbritic plateau (or, alternatively, with transgression of an intervening morphological sill), or with a peak of contemporaneous volcanic activity. This event would be tentatively dated as late? Pelsonian.

Petrofacies A3 is represented in the prograding clastics of the uppermost Bellano Formation, from the Acquaseria redbeds to the microconglomeratic coastal sandstones of Val Muggiasca. Petrofacies A3 is identical to A1 but for a slight, though significant, enrichment in quartz (up to sublitharenitic compositions) along with absence of chessboard albite. Petrologic intervals A1 and A3 can be reliably distinguished only in continuous sections where the interposed lithic-rich interval can be recognized.

The reduction in volcanic detritus and return to detrital modes very similar to those of petrofacies A1 again can be explained either with the end of parossistic volcanism or with alternate uplift of Collio-type, volcanic-rich basins and basement highs, coupled with diversions and captures of river courses. A major role surely played the Grona basement high located between Lake Como and Lake Lugano (Gianotti, 1968; Cassinis & Gianotti, 1983), where the Upper Permian to Smithian succession is missing. Its uplift could have provided arkosic detritus to the Servino fan-deltas around the Smithian-Spathian boundary (S3), whereas it was partly covered and bypassed by increasing amounts of volcanic detritus from the Lugano area in the Anisian (A1 to A2). Both renewed uplift and eustatic regression at the close of the Pelsonian can explain the return to more feldspathic composition in the uppermost Bellano Formation and Albiga Member clastics. A few metres-thick sandstones belonging to petrologic interval A3 are present also on the Grona high.

On the other hand, Early to mid-Anisian magmatism might be indicated by radiometric dates around 240 Ma recorded at various sites of the Southern Alps (Boriani et al., 1985; Sassi et al., 1985). Fluorite dykes cutting Anisian Bellano-type clastics and sealed by Illyrian S. Salvatore dolomites west of Lake Lugano (F. Rodeghiero, P. Neri & C. Rossi, pers. comm. 1993), and widespread adularia cements in the Bellano Formation, represent further clues to a pre-Late Anisian hydrotermal activity.

In the Calchera Valley, siliciclastics intercalated within the 50 m-thick Albiga Member are characterized by the same detrital modes, suggesting that the Illyrian transgression could have been mainly eustatically-driven and not associated with significant tectonism in the source areas. Thin tuffaceous horizons in the Albiga Member, however, testify to explosive volcanic activity, widespread at this stage in the whole Southern Alps (De Zanche et al., 1979, 1993).

Conclusions

Detrital modes of sandstones from the Upper Permian to Upper Anisian succession of the Western Southern Alps group in 8 petrofacies, characterizing superposed and laterally correlatable sets of strata.

Although sandstone mineralogy can be controlled by several factors, including provenance, climate, sedimentary processes and diagenesis, Permo-Anisian compositional trends are thought to largely mirror the complex interplay of tectonism and erosion of source rocks through time. Sedimentary processes do account for short-term compositional changes observed at specific stratigraphic intervals, such as the deltaic cyclothems of the Prato Solaro Member, or for facies-controlled lateral trends, as for the lithic-rich interval of the Bellano Formation. However, they explain only a minor part of the variance of compositional parameters throughout the Permo-Anisian succession. Even correlation between grain size and feldspar abundance is very weak (correl. coeff. -.25 on 184 samples).

Climatic control is difficult to evaluate; the Carniola di Bovegno evaporitic dolostones, testifying to an arid episode around the Scythian-Anisian boundary, lack interbedded sandstones.

Carbonate replacements of unstable framework grains severely affected several Scythian and Anisian samples, but their detrital modes cluster consistently with interbedded non-carbonatic sandstones, pointing to only minor diagenetic modification of mineralogical composition. Also in the Verrucano Lombardo, in spite of widespread squeezing of weaker grains during burial, pervasive growth of sericite and anchimetamorphic textural changes, detrital modes have not been significantly altered by diagenesis (Helmold et al., 1984).

Eustasy can only indirectly influence mineralogy, as for the major late Griesbachian transgression (cycle UAA-1.2 on the Haq et al., 1988 time scale), when both mineralogically stable and texturally mature quartzose sandstones were produced by widespread encroachement of high-energy, shallow-marine environments, in turn induced by a major eustatic rise (Holser & Magaritz, 1987). The abrupt compositional transitions from subarkosic petrofacies S2 to arkosic petrofacies S3 and from arkosic petrofacies S3 to litho-feldspathic petrofacies A1 coincide respectively with the regression followed by the early Spathian transgression (cycle UAA-1.4 on the Haq et al., 1988 time scale) and with the earliest Anisian regression. Since petrofacies boundaries reflect drastic changes in the source areas, such coincidences suggest that variations of relative sea-level were tectonically rather than eustatically-driven. The major Illyrian transgression did not affect detrital modes.

Geodynamic evolution.

The studied Upper Permian to Upper Anisian succession represents the lower part of the first-order Westphalian to Carnian megacycle, comprised between the Hercynian Orogeny and the initial Late Triassic rifting stages which will lead to the opening of the Jurassic Ligurian-Piedmont Ocean (first megasequence of Gaetani et al., 1996). The succession is bracketed between what has been called the Saalian "Phase" (a post-collisional extensional stage characterized by strong differential subsidence of intramontane basins and emplacement of huge ignimbritic plateaux; Stille, 1924; Palatinian "Phase" of Kozur, 1980) and the Labinic "Phase" (starting in the Western Southern Alps with rapid deepening of the Prezzo-Buchenstein troughs, explosive volcanism and disappearance of siliciclastics in Western Lombardy; Stille, 1941 in Goguel, 1952). Composition and geometry of several clastic bodies, which are mostly laterally confined and derived locally, are consistent with a continental wrench setting. Rapid sinking of pull-apart basins, fed by deeply eroded adjoining uplifted blocks, was in fact commonly followed by tectonic inversions or renewed crustal-contaminated felsic magmatism along "leaky" strike-slip faults (Massari, 1988).

Four major steps in the Permo-Anisian evolution of the Western Southern Alps are herein identified.

1) The Upper Permian to lower-middle Griesbachian clastics (Verrucano Lombardo and Prato Solaro Member) document gradual attenuation of relief and peneplanation of source areas. The Lower Permian ignimbritic plateaux were progressively dissected (lithic petrofacies P1), until erosion reached more conspicuously into the Hercynian basement and overlying pre-volcanic quartzose siliciclastics (quartzo-lithic petrofacies P2 to sublitharenitic petrofacies S1). Boundaries between petrologic intervals P1, P2 and S1 are abrupt and most likely marked by significant hiatuses.

2) The upper Griesbachian to Smithian middle lithozone of the Servino Formation (subarkosic petrofacies S2) is a tabular body of mature and quartzose coastal sandstones, deposited during a stage of transgression and reduced tectonic activity (Fig. 12).

3) Around the Smithian-Spathian boundary, laterally confined submature arkoses (arkosic petrofacies S3) were deposited in fan-deltas fed by gneissic to granitoid basement rocks uplifted west of Acquaseria, where this lithozone is lacking (Recoaro "Phase" of De Zanche & Farabegoli, 1981). The geometry of this clastic wedge rules out major climatic control (arkoses are thus "tectonic" and not "climatic"; Krynine, 1948, p. 154; Folk, 1974, pp. 132-135). The depocenter was located along the axis of Lake Como. Sand-sized feldspathic detritus fades out eastward in the Orobic Alps, where it is present only around the boundary between the middle and upper lithozones of the Servino Formation. These alternating sandstone beds of quartzose and more feldspathic composition are overlain by the widespread Spathian mudrocks of the Servino Formation upper lithozone (Fig. 12).

4) Close to the Spathian-Anisian boundary, a marked increase in both volcanic and metamorphic detritus, well testified in the Anisian Bellano Formation (litho-feldspathic petrofacies A1 to A3; Fig. 7), points to strong tectonic activity and inversion of Collio-type basins (Montenegro "Phase" of Milovanovic, 1954; Brandner, 1984). On the other hand, stratigraphic and radiometric data might support continuing volcanic to hydrothermal activity.

The Permo-Triassic evolution of the Southern Alps has been recently interpreted in a general rifting framework (Gosso et al., 1995). Continental stretching would have favoured intrusion of gabbroic bodies in the lower crust, such as the Sondalo Gabbro (Rb-Sr biotite age of 24±4 MA in Boriani et al., 1985). Palinspastic restoration for dextral strike-slip motion along the Insubric Line would place this body close to the study area; therefore magma underplating could have been responsible for uplift of basement highs either in the Olenekian (Petrofacies S3; time scale of Haq et al., 1988; Harland et al., 1989) or in the Anisian (Petrofacies A; time scale according to Brack & Rieber, 1993).

Quantitative petrographic analysis documents the importance of such tectonic phases at the Smithian/

Spathian and Scythian/Anisian boundaries, both marked by abrupt mineralogical changes testifying to rejuvenation of relief.

Modal analysis allowed recognition of the mid-Servino petrofacies S2 to S3 and Bellano petrofacies A1 to A3 also west of Acquaseria, where the Verrucano Lombardo, the Prato Solaro Member, most of the Servino Formation, the Carniola di Bovegno and most of the Bellano Formation are lacking. The improper term "Servino-Verrucano Series", used by previous authors in the area west of Lake Como, should thus be dismissed.

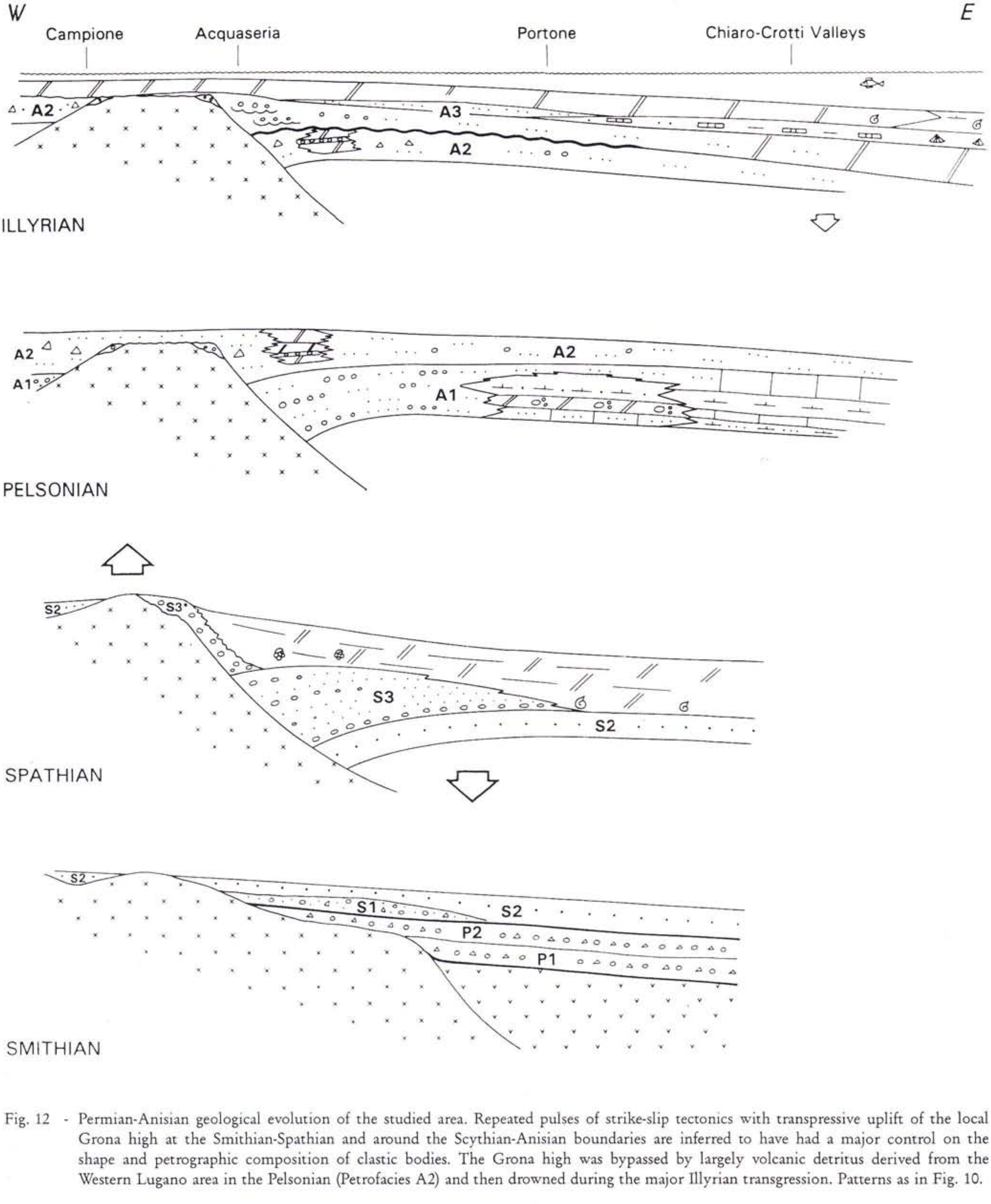

Fig. 12 - Permian-Anisian geological evolution of the studied area. Repeated pulses of strike-slip tectonics with transpressive uplift of the local Grona high at the Smithian-Spathian and around the Scythian-Anisian boundaries are inferred to have had a major control on the shape and petrographic composition of clastic bodies. The Grona high was bypassed by largely volcanic detritus derived from the Western Lugano area in the Pelsonian (Petrofacies A2) and then drowned during the major Illyrian transgression. Patterns as in Fig. 10.

Sample	Unit	Pt	GSZ	SRT	Q	F	L	C/Q	P/F	V/L	Qs	Qp	Pl	Af	VRF	MRF	PRF	ARF	Cl	NCl	Acc	Mat	Cem	Aut	TOT
S.Martino																									
CF 47	B	**A2**	420	M/W	32,9	11,4	55,7	0,22	0,00	0,98	17,3	5,3	-	7,7	41,0	-	1,7	-	-	-	-	19,0	7,7	0,3	100
CF 48	B	**A2**	700	M/P	36,2	4,3	59,6	0,35	0,00	0,99	17,3	10,0	-	2,7	47,0	-	1,3	-	-	-	0,3	9,7	8,0	3,7	100
CF 54	B	**A1**	415	M/P	62,6	21,5	15,9	0,39	0,07	1,00	23,3	16,0	1,0	12,0	10,3	0,3	2,0	-	-	-	2,0	12,0	19,3	1,7	100
CF 52	B	**A1**	670	P	69,9	13,1	17,0	0,51	0,04	1,00	22,3	24,7	0,3	8,7	12,0	-	0,7	-	-	-	0,3	10,0	21,0	-	100
Cornaredo																									
CR 6	S	**S2**	385	M/P	93,8	5,0	1,3	0,17	0,00	1,00	41,0	8,3	-	2,3	0,7	-	1,0	-	-	-	0,3	1,0	8,7	36,7	100
CR 5	S	**S2**	600	P	91,7	4,8	3,6	0,23	0,00	1,00	39,0	12,0	-	2,7	2,0	-	0,3	-	-	2,0	1,3	7,3	10,3	23,0	100
CR 4	S	**S2**	650	P	93,8	4,5	1,7	0,16	0,12	1,00	46,0	9,0	0,3	2,3	1,0	-	-	-	-	-	0,3	3,0	7,7	30,3	100
Campione																									
CF 73	B	**A2**	275	M	53,8	12,6	33,5	0,30	0,09	0,93	19,0	9,7	0,3	4,0	19,7	0,3	7,3	-	1,0	-	-	-	2,3	36,3	100
CF 71bis	B	**A2**	1200	P	44,7	12,1	43,3	0,21	0,00	0,89	23,3	6,7	-	7,7	28,0	1,3	4,7	-	-	-	0,7	5,0	13,0	9,7	100
CF 71	B	**A2**	240	M	68,4	11,9	19,7	0,08	0,04	0,97	40,0	3,3	-	7,3	12,3	1,0	0,3	-	-	-	0,7	7,7	15,0	12,3	100
CF 72	B	**A2**	310	M	64,5	15,0	20,5	0,26	0,03	0,76	31,3	11,0	0,3	9,3	10,3	0,7	3,7	-	-	-	0,7	3,3	10,7	18,7	100
CF 70bis	B	**A2**	350	M/P	54,9	13,6	31,5	0,18	0,06	0,86	33,1	7,6	0,7	8,9	21,2	0,7	6,0	-	-	-	1,0	2,0	14,2	4,6	100
CF 70	B	**A2**	210	M/W	56,1	9,1	34,8	0,13	0,06	0,91	32,0	4,7	0,3	5,3	20,0	0,7	2,0	-	-	-	-	4,3	23,0	7,7	100
CF 69	B	**A2**	265	M/P	52,2	13,9	33,9	0,17	0,04	0,85	22,7	5,3	0,3	6,3	19,3	1,0	5,0	-	0,7	-	-	-	3,3	36,3	100
CF 69+	B	**A2**	1400	P	37,3	10,1	52,5	0,30	0,04	0,90	16,0	8,0	0,3	6,0	34,7	1,7	5,7	-	-	-	-	6,0	13,0	8,7	100
CF 68+	B	**A2**	800	P	50,0	15,4	34,6	0,33	0,19	0,97	21,0	11,3	2,0	6,7	23,3	0,7	4,3	-	0,7	-	0,3	-	13,7	16,0	100
CF 68	B	**A2**	300	M/P	61,1	11,8	27,1	0,11	0,15	0,90	39,3	5,3	1,3	6,0	19,0	0,7	4,7	-	-	-	2,3	9,3	11,3	0,7	100
CF 67	B	A2	475	P	60,0	7,4	32,6	0,38	0,00	0,84	21,5	14,2	-	4,0	17,5	1,3	4,3	-	-	-	0,7	5,3	15,5	15,8	100
Scirona																									
NR 9	B	A3	470	M	62,0	22,3	15,6	0,60	0,05	0,96	14,3	22,3	0,7	10,0	9,0	1,0	3,7	-	-	-	2,3	12,0	13,3	11,3	100
NR 8	S	S3*	550	P	81,6	14,1	4,3	0,53	0,00	0,90	28,0	33,7	-	10,0	3,0	1,0	2,7	-	-	-	1,0	6,0	9,0	5,7	100
Pairolo																									
NR 18	B	A3	180	P	81,6	11,0	7,4	0,16	0,06	0,92	37,3	7,0	0,3	5,3	3,7	-	1,0	-	-	-	-	4,0	3,7	37,7	100
NR 19	B	A3	380	P	60,4	18,9	20,7	0,54	0,31	0,89	17,3	24,0	4,0	8,7	13,7	1,0	5,3	-	-	-	3,0	2,7	13,7	6,7	100
Acquaseria																									
DP 24	B	A3	285	VP	63,2	17,2	19,5	0,34	0,40	0,88	23,3	12,7	4,0	6,0	10,3	-	1,0	-	0,7	-	-	-	4,3	37,7	100
DP 23	B	A3	700	M/P	62,9	19,0	18,1	0,60	0,20	0,98	16,3	29,7	3,0	11,0	15,0	1,0	3,0	0,3	-	-	-	12,3	8,0	0,3	100
DP 21	B	A3	900	M/P	70,6	15,1	14,2	0,72	0,09	0,93	13,3	37,0	1,0	8,3	9,7	0,3	2,7	-	-	-	-	14,7	11,7	1,7	100
DP 20	B	A3	1000	P	73,9	11,8	14,3	0,53	0,00	0,93	23,0	26,7	-	6,7	9,3	-	2,0	-	-	-	1,0	18,7	9,3	3,3	100
DP 19	B	A3	390	M/P	60,1	17,8	22,1	0,52	0,18	0,87	19,3	22,3	2,0	10,3	13,7	3,0	1,0	-	-	-	3,3	7,0	16,0	2,0	100
DP 18	B	A2	170	VP	54,1	13,2	32,7	0,29	0,24	0,92	19,7	8,3	1,3	5,0	16,3	1,0	2,0	-	-	-	4,3	30,0	7,3	4,7	100
DP 17	B	A2	130	P	52,5	16,1	31,4	0,27	0,42	0,97	15,0	5,7	2,7	3,7	12,3	-	0,3	-	-	-	1,7	8,3	7,7	42,7	100
DP 16	B	A2	460	P	64,4	19,1	16,5	0,32	0,28	0,97	25,3	13,0	3,3	8,7	10,0	0,7	1,7	-	-	-	0,3	5,7	17,0	14,3	100
DP 14	B	A2	850	P	52,2	14,5	33,3	0,55	0,20	0,93	14,7	19,7	2,0	7,3	21,3	0,7	3,3	-	-	-	1,3	6,7	9,7	13,3	100
DP 13	B	A1	1300	P	62,1	17,9	20,1	0,59	0,10	0,98	14,7	27,3	1,3	11,0	16,7	0,3	3,3	-	-	-	-	13,7	9,3	2,3	100
DP 77	B	A1	330	P	72,4	19,0	8,6	0,43	0,32	0,93	21,0	16,7	3,0	7,0	5,3	0,3	1,0	-	-	-	1,0	3,0	5,7	36,0	100
DP 76	B	A1	270	M/P	63,8	16,7	19,5	0,35	0,28	1,00	24,0	13,0	2,7	6,7	11,3	-	0,3	-	-	-	-	12,0	11,3	18,7	100
DP 75	B	A1	340	M/P	67,7	15,6	16,7	0,34	0,24	0,90	26,7	14,3	2,3	7,3	9,7	-	1,7	-	-	-	1,0	14,3	8,0	14,7	100
DP 74	B	A1	315	P	59,4	20,3	20,3	0,32	0,14	0,93	25,7	13,3	1,7	11,0	13,3	0,7	3,3	-	-	-	-	22,0	8,3	0,7	100
DP 73	B	A1	290	P	55,5	20,4	24,1	0,45	0,26	0,91	17,0	16,0	3,0	9,7	14,0	0,7	3,3	-	-	-	1,0	9,0	9,0	17,3	100
DP 72	S	S3*	500	P	76,9	12,7	10,5	0,36	0,10	0,83	34,7	21,0	1,0	7,7	6,7	-	5,3	-	-	-	-	5,7	17,7	0,3	100
DP 93	S	S3	675	P	71,3	22,1	6,7	0,60	0,02	0,54	17,7	28,0	0,3	14,0	2,3	-	2,7	-	-	-	1,3	4,0	18,7	11,0	100
DP 12	S	S3	480	M/W	68,2	28,4	3,3	0,56	0,18	1,00	17,7	27,0	3,0	14,7	2,3	-	5,7	-	-	-	1,3	11,7	15,7	1,0	100
DP 11	S	S3*	140	M/W	78,8	17,3	3,9	0,14	0,64	0,71	40,0	6,7	0,7	9,7	1,7	-	1,0	-	-	-	1,7	16,0	21,7	1,0	100
DP 94	S	S2	1100	VP	86,7	12,7	0,6	0,35	0,00	1,00	29,3	16,0	-	6,7	0,3	-	0,3	-	-	1,0	1,3	8,3	5,0	31,7	100
DP 71	S	S2	160	VP	87,8	8,6	3,6	0,21	0,00	1,00	31,7	8,7	-	4,0	2,0	0,3	-	-	0,3	-	1,7	12,7	4,3	34,3	100
DP 70	S	S2	115	VP	80,2	14,9	5,0	0,22	0,13	1,00	21,0	6,0	0,7	4,3	1,7	-	-	-	-	-	5,3	8,7	9,0	43,3	100
DP 69	S	S2	65	M/W	79,1	14,3	6,6	0,04	0,08	1,00	23,0	1,0	0,3	4,0	2,0	-	-	-	-	-	7,0	19,3	9,3	34,0	100
DP 68	S	S2	95	M/P	83,5	12,4	4,1	0,07	0,08	1,00	24,0	2,0	0,3	3,7	1,3	1,0	-	-	-	1,0	8,0	20,3	18,0	20,3	100
DP 67	S	S2	110	P	80,9	11,8	7,3	0,01	0,08	1,00	26,3	3,0	0,3	4,0	3,0	-	-	-	-	1,0	2,3	45,7	10,3	4,0	100
DP 66	S	S2	125	VP	84,7	12,7	2,5	0,12	0,07	1,00	29,0	4,0	0,3	4,7	1,0	0,3	-	-	-	0,7	1,7	14,0	5,7	38,7	100
DP 95	S	S2	75	W	79,0	13,4	7,6	0,03	0,00	0,89	30,3	1,0	-	5,0	2,7	-	0,7	-	-	-	9,3	21,0	12,0	18,0	100
Bellano																									
G 1891	B	A3	580	M/P	60,3	21,0	18,7	0,52	0,16	0,95	20,3	21,0	2,0	12,3	12,3	2,0	1,3	-	-	-	0,7	8,3	19,3	0,3	100
G 1890	B	A3	440	M	63,2	18,9	18,0	0,49	0,42	0,93	22,5	23,2	4,6	6,6	12,2	3,3	3,0	-	-	-	3,3	12,3	9,0	-	100
G 1889	B	A3	505	M/P	59,2	22,7	18,0	0,55	0,48	0,95	15,3	22,3	6,0	7,7	12,3	4,3	2,3	-	-	-	1,3	1,3	18,3	8,7	100
G 1881	B	A1	970	M	67,5	20,8	11,8	0,38	0,42	1,00	34,6	18,8	6,6	8,6	10,2	1,0	4,0	-	-	-	0,7	1,3	3,3	10,9	100
G 1879	B	A1	540	M/P	67,1	19,7	13,2	0,44	0,31	0,90	27,3	21,7	3,7	9,3	9,3	2,7	2,0	-	-	-	2,0	2,7	18,0	1,3	100
G 1877	B	A1	890	P	73,8	15,2	11,0	0,54	0,31	0,96	23,1	28,7	3,0	6,9	8,9	5,3	2,3	-	-	-	0,3	4,3	11,2	6,3	100
G 1876	B	A1	855	M/P	67,1	16,2	16,7	0,42	0,23	1,00	23,3	18,7	2,7	8,3	13,3	3,0	2,7	-	-	-	1,3	8,0	18,0	0,7	100
DS 151	B	A1	595	M/P	64,4	16,9	18,7	0,61	0,08	0,93	16,6	27,6	1,0	10,9	9,3	2,6	1,3	0,6	-	-	0,3	10,6	4,9	13,9	100
DS 150	B	A1	530	M/P	65,0	19,2	15,9	0,35	0,17	1,00	27,0	16,3	2,0	10,3	13,3	0,3	2,0	-	-	-	-	0,3	27,7	0,7	100
DS 149	B	A1	590	M/W	72,4	17,8	9,8	0,34	0,13	1,00	34,7	18,0	1,3	11,7	7,3	0,7	0,7	-	-	-	-	0,6	25,0	-	100
DS 148	B	A1	655	M/P	66,8	16,0	17,2	0,64	0,18	0,90	16,1	32,2	2,0	9,5	12,5	3,3	2,6	-	-	-	-	7,6	4,6	9,5	100
DS 146	B	A1	285	P	64,2	19,4	16,4	0,36	0,41	0,94	25,9	13,9	5,3	6,6	10,3	3,0	1,7	-	-	3,3	3,7	8,0	2,0	16,3	100
DS 147	B	A1	385	M/P	56,4	23,7	19,9	0,49	0,20	0,93	19,0	19,0	2,7	11,7	13,3	2,0	2,7	-	-	-	3,7	5,0	15,0	6,0	100
G 1874	B	A1	400	P	58,2	29,4	12,4	0,38	0,12	1,00	23,2	14,2	2,3	15,6	8,6	0,3	2,3	-	2,3	-	0,3	0,3	1,3	29,1	100
DS 145	S	A1	475	P	61,6	17,5	21,0	0,42	0,35	0,98	24,3	18,3	4,3	7,7	16,3	3,0	2,3	-	-	-	10,0	6,7	4,7	2,3	100
DS 142	S	S3	830	M	70,0	19,3	10,7	0,41	0,02	0,92	32,7	22,3	0,3	14,0	4,0	2,0	1,0	-	-	-	0,3	10,0	12,7	0,7	100
DS 141	S	S3	250	M/W	66,4	29,9	3,7	0,30	0,38	0,75	32,3	13,7	7,7	13,0	1,7	2,3	0,7	-	-	-	0,3	1,0	23,3	4,0	100
DS 140	S	S3	240	M	65,0	27,5	7,5	0,41	0,29	1,00	24,6	16,9	5,0	12,0	4,6	1,0	2,3	-	-	-	5,0	2,6	22,6	3,3	100
DS 144	P	S2	460	M/P	87,0	7,1	5,9	0,30	0,65	1,00	47,0	20,0	2,0	2,0	4,7	1,3	2,7	-	-	-	1,3	11,3	3,7	4,0	100
DS 143	V	P2	580	M	58,4	4,7	36,9	0,52	0,33	0,93	20,6	23,9	1,3	2,0	25,6	4,3	1,3	-	-	-	2,3	13,3	1,3	4,0	100
S.S. 36																									
G 1507	B	A3	225	M	75,2	11,7	13,1	0,26	0,61	1,00	28,3	10,0	3,7	2,3	6,7	-	-	-	-	-	4,0	2,7	7,0	35,3	100
G 1501	B	A2	355	M	47,0	20,3	32,7	0,56	0,34	0,96	12,0	16,3	4,7	7,3	17,3	3,3	2,0	-	-	-	1,7	12,0	7,3	16,0	100
G 1503	B	A1	1250	M	71,9	12,4	15,7	0,42	0,11	0,94	29,0	21,0	1,0	7,0	10,3	0,7	0,7	-	-	-	0,3	5,0	23,7	1,0	100
G 1502	B	A1	410	M/P	62,0	13,0	25,0	0,52	0,25	0,96	16,7	20,0	2,0	5,7	14,7	1,3	1,0	-	-	-	1,7	15,0	18,7	3,3	100
G 1510	B	A1	515	M/P	66,5	18,2	15,3	0,30	0,16	0,90	30,0	13,7	2,0	9,7	9,3	3,0	-	-	-	-	0,3	4,7	25,3	2,0	100
G 1495	S	S3	600	M	63,5	27,9	8,6	0,41	0,33	1,00	23,7	17,7	6,0	11,7	6,7	0,7	3,0	-	-	-	1,0	2,7	20,7	6,3	100
G 1489	S	S3	265	M	67,2	31,2	1,6	0,16	0,33	1,00	35,3	6,7	6,7	13,0	0,7	-	1,7	-	-	-	-	-	18,3	17,7	100
G 1492	S	S3	550	M	53,7	35,6	10,7	0,39	0,25	1,00	20,0	14,6	5,0	17,0	8,3	1,6	5,3	-	-	-	0,3	18,0	9,7	-	100
G 1490	S	S3	70 ?	P	52,7	32,7	14,6	0,42	0,34	0,95	13,7	10,0	5,0	10,3	6,3	1,3	1,3	-	-	-	1,3	42,7	3,7	4,3	100
G 1493	S	S3	830	M/P	63,0	33,1	3,9	0,51	0,32	1,00	16,0	17,0	5,3	12,6	2,7	5,0	1,7	-	-	-	0,7	1,3	13,0	24,7	100
G 1486	P	S1	1380	M/P	64,9	7,5	27,6	0,58	0,44	0,96	17,3	29,0	1,3	1,7	19,0	3,7	3,7	-	-	-	1,7	18,7	3,7	0,3	100
G 1488	P	S1	350	M	59,5	5,9	34,6	0,64	0,58	0,94	12,0	24,3	1,3	0,3	23,0	5,7	2,7	-	,	-	0,7	16,0	2,7	11,3	100
Calchera																									
SR 18	D	A3	260	M	62,2	22,2	15,7	0,41	0,76	0,97	20,3	14,7	10,0	3,3	9,3	2,7	1,3	-	0,7	-	3,3	1,3	6,0	27,0	100
SR 13	B	A3	640	M/P	73,2	11,6	15,2	0,70	0,52	0,90	12,7	30,0	2,0	3,3	9,7	7,0	1,3	-	-	-	0,3	3,0	4,7	26,0	100
SR 10	B	A2	270	P	54,4	20,8	24,8	0,57	0,31	0,93	7,0	12,0	2,7	5,7	10,3	3,0	1,0	-	25,0	-	-	1,7	0,3	31,3	100
SR 12	B	A2	600	P	65,4	13,8	20,7	0,63	0,69	0,79	13,7	22,3	4,3	2,7	11,3	7,7	0,3	0,3	-	-	0,7	4,3	3,3	29,0	100
SR 140	B	A2	425	M	57,6	13,7	28,8	0,60	0,61	0,88	13,3	20,0	3,7	3,3	17,7	9,0	1,0	0,3	-	-	1,0	3,7	5,3	21,7	100
SR 9	B	A1	870	P	66,0	14,0	20,0	0,72	0,21	0,88	9,3	30,3	1,7	6,7	12,3	6,0	0,3	-	-	-	2,3	11,7	16,7	2,7	100
SR 11	B	A1	595	M/P	62,4	17,7	19,9	0,72	0,58	0,93	11,7	32,3	7,0	5,7	14,3	3,7	0,7	-	-	-	-	11,0	7,7	6,0	100
SR 8	B	A1	470	M/P	66,0	17,8	16,2	0,71	0,56	0,81	9,0	27,0	4,2	4,5	9,3	6,7	0,3	0,3	1,3	-	2,6	4,2	3,9	26,5	100
SR 7	B	A1	235	M	57,4	23,5	19,1	0,70	0,60	0,77	9,7	23,0	6,7	5,0	9,0	7,3	0,3	-	-	-	7,0	14,0	6,3	11,7	100
SR 6	B	A1	705	M/P	64,3	18,3	17,4	0,68	0,19	0,75	10,3	30,7	2,0	8,7	13,0	12,0	1,7	-	-	-	1,0	5,3	12,3	3,0	100
SR 132	B	A1	415	M/P	53,7	23,7	22,5	0,66	0,32	0,94	10,7	27,7	4,7	11,3	12,7	4,7	2,3	-	-	-	2,0	13,7	9,7	0,7	100
V. Chiaro																									
DS 43	B	A3	590	M/P	62,4	25,9	11,7	0,56	0,27	0,94	20,9	28,4	5,4	14,1	9,0	1,5	2,7	-	-	-	0,6	3,3	14,1	-	100
DS 44	B	A2	465	M	59,5	25,1	15,4	0,59	0,30	0,94	17,3	26,7	5,3	11,7	11,3	1,7	1,7	-	-	-	0,7	0,7	13,3	9,7	100
DS 45	B	A1	470	P	53,2	30,2	16,6	0,52	0,34	0,94	15,0	17,7	6,3	12,0	11,0	2,7	3,7	-	0,7	-	2,7	-	8,0	20,3	100
DS 49	B	A1	330	VP	71,4	17,1	11,5	0,33	0,18	0,92	29,1	18,5	2,3	10,3	8,6	1,3	0,7	-	-	-	2,0	0,3	4,6	22,2	100
DS 50	B	A1	370	M	58,3	23,5	18,1	0,45	0,18	0,98	20,5	17,5	2,0	12,2	11,9	1,7	1,7	-	-	-	1,7	-	1,0	29,8	100
DS 51	B	A1	400	M	55,1	24,2	20,8	0,45	0,18	0,98	22,6	18,6	3,3	14,6	15,9	2,0	1,3	-	-	-	2,0	-	11,6	8,0	100
DS 55	A	A1	240	P	60,5	28,2	11,4	0,38	0,63	1,00	26,5	15,2	12,9	6,9	8,6	2,0	0,7	-	-	-	8,6	2,3	9,6	6,6	100

Sample	Unit	Pf.	GSZ	SRT	Q	F	L	C/Q	P/F	V/L	Qs	Qp	Pl	Af	VRF	MRF	PRF	ARF	CI	NCI	Acc	Mat	Cem	Aut	TOT
V. Crotti																									
LD 33	B	**A1**	575	M/P	60,3	23,8	15,8	0,72	0,28	0,83	10,3	28,4	4,8	12,2	9,7	6,1	1,6	-	-	-	2,9	5,1	17,1	1,6	100
LD 30	M	**A1**	430	M	63,5	23,0	13,5	0,38	0,29	1,00	19,3	12,0	2,7	7,7	6,7	0,7	0,3	-	10,7	-	1,3	-	1,3	37,3	100
*selected outcrops **																									
DS85	B	**A1**	935	M/P	58,4	23,7	18,0	0,55	0,33	0,98	19,2	24,3	6,1	11,8	14,1	1,0	1,9	-	-	-	0,3	0,6	14,7	5,8	100
DS120	M	**A1**	405	VP	59,5	12,5	28,0	0,40	0,20	0,98	23,3	15,7	1,7	6,3	13,3	1,0	0,7	-	-	-	0,7	22,0	7,7	7,7	100
DS80	S	**S3**	565	M/P	66,5	16,7	16,7	0,23	0,08	0,95	38,7	11,3	1,0	11,7	12,0	1,0	-	-	-	-	-	0,3	22,0	2,0	100
DS95	S	**S3**	420	P	50,9	33,2	15,9	0,45	0,19	1,00	19,3	16,3	4,6	16,6	11,6	1,0	3,6	-	-	-	1,7	7,0	17,6	0,7	100
DS90	S	**S3**	375	M	52,2	34,1	13,7	0,43	0,18	0,97	22,0	17,0	4,7	21,0	10,0	0,7	-	-	-	-	-	0,3	20,3	4,0	100
DS108	S	**S3**	298	M/P	60,1	25,2	14,7	0,24	0,47	1,00	35,7	10,7	9,3	10,0	12,0	1,0	0,7	-	-	-	0,3	6,0	13,7	0,7	100
DS110	S	**S3**	300	M/P	55,2	29,2	15,6	0,31	0,47	1,00	26,7	11,0	9,7	11,0	10,7	0,7	1,0	-	-	-	0,7	-	17,0	11,7	100
DS130	S	**S3**	190	M/W	57,7	33,2	9,2	0,31	0,26	0,89	25,5	11,3	5,3	14,5	5,0	0,7	2,7	-	-	-	2,0	4,3	15,9	12,3	100
DS100	P	**S1**	535	M/P	76,5	6,3	17,2	0,39	0,47	0,90	36,2	22,5	2,3	2,3	8,6	2,0	0,7	-	-	-	2,0	13,0	9,6	1,0	100
Cûgnoletta																									
DS 165	S	**S2**	335	M	86,8	2,1	11,1	0,34	1,00	0,95	36,0	18,7	1,3	-	6,7	-	0,3	-	-	-	0,3	15,7	20,3	0,7	100
DS 164	S	**S2**	145	W	97,3	0,5	2,2	0,18	1,00	1,00	48,3	11,0	0,3	-	1,3	-	-	-	-	-	0,7	11,7	17,0	9,7	100
DS 163	S	**S2**	675	M	98,4	0,0	1,6	0,34	ind.	1,00	40,0	20,3	-	-	1,0	-	-	-	-	0,3	-	3,7	14,7	20,0	100
DS 162	S	**S2**	240	W	94,4	0,0	5,6	0,23	ind.	0,89	38,7	12,0	-	-	2,7	0,7	-	-	-	0,7	0,7	2,3	22,3	20,0	100
DS 161	S	**S2**	290	M/P	94,8	1,0	4,1	0,28	1,00	0,62	43,3	17,3	0,7	-	1,7	2,0	-	-	-	-	1,3	11,3	17,7	4,7	100
DS 160	S	**S2**	240	W	95,0	0,0	5,0	0,18	ind.	1,00	41,3	9,0	-	-	2,7	-	-	-	-	-	0,7	1,7	20,0	24,7	100
DS 159	S	**S2**	875	P	95,2	0,0	4,8	0,43	ind.	0,83	22,3	17,3	-	-	2,0	0,3	-	-	-	0,3	0,3	-	1,0	56,3	100
DS 158	S	**S2**	235	M/W	97,3	0,0	2,7	0,14	ind.	1,00	51,7	8,7	-	-	1,7	-	-	-	-	-	1,0	3,3	19,0	14,7	100
DS 157	P	**S1**	415	P	74,2	0,0	25,8	0,27	ind.	0,98	33,0	12,0	-	-	15,3	-	-	0,3	-	-	0,7	8,3	13,0	17,3	100
DS 156	P	**S1**	1800	VP	71,0	0,0	29,0	0,50	ind.	0,98	23,7	23,7	-	-	19,0	-	-	0,3	-	-	1,3	12,0	-	20,0	100
DS 155	V	**P2**	550	P	65,8	1,6	32,6	0,33	1,00	0,95	27,3	14,0	1,0	-	20,7	0,7	-	-	-	-	0,7	16,0	9,0	10,7	100
DS 154	V	**P2**	240	M/W	75,3	0,7	24,0	0,19	1,00	0,86	29,7	7,0	0,3	-	10,0	1,7	-	-	-	-	2,3	19,7	10,0	19,3	100
Comasira																									
DS 75	S	**S2**	320	M/P	95,1	2,5	2,5	0,22	0,50	1,00	37,2	10,3	0,6	0,6	1,2	0,6	-	-	7,2	-	0,6	10,3	1,2	30,0	100
DS 74	S	**S2**	760	M/W	86,8	9,8	3,4	0,22	0,25	1,00	45,0	13,3	1,7	4,7	2,7	-	1,0	-	-	-	0,3	1,0	3,0	27,3	100
DS 73	S	**S2**	855	M	89,6	5,5	4,9	0,23	0,40	1,00	40,7	12,2	1,3	1,7	3,6	-	1,0	-	0,3	-	1,0	7,3	1,0	29,8	100
DS 72	S	**S2**	560	P	86,1	13,2	0,7	0,23	0,10	1,00	34,5	10,3	0,7	5,6	0,3	0,7	0,7	-	3,3	-	2,3	-	0,7	40,9	100
DS 71	S	**S2**	570	M	81,9	13,0	5,1	0,38	0,26	1,00	29,7	18,0	2,0	5,0	2,7	0,7	1,0	-	6,3	-	0,3	-	1,0	33,3	100
DS 70	S	**S2**	650	P	74,3	12,1	13,6	0,36	0,23	1,00	33,4	18,9	2,0	6,6	5,3	0,3	-	-	1,3	-	4,3	10,3	1,0	16,5	100
DS 69	S	**S2**	335	P	73,7	14,1	12,2	0,33	0,21	0,91	33,0	16,7	2,0	7,7	3,3	0,3	0,7	-	-	-	5,3	28,0	2,3	0,7	100
DS 76	P	**S1**	930	M/P	84,7	7,2	8,1	0,38	0,18	0,95	40,3	24,0	0,7	4,3	6,7	2,3	0,3	-	-	-	-	6,3	14,7	0,3	100
DS 68	P	**S1**	680	M	87,6	8,4	4,0	0,34	0,00	0,90	45,8	23,5	-	6,1	2,6	1,0	1,3	-	-	-	1,0	1,7	16,6	0,3	100
DS 67	P	**S1**	588	M	84,2	11,5	4,3	0,30	0,04	1,00	45,7	20,0	0,3	8,3	3,3	-	0,3	-	-	-	-	1,3	19,7	1,0	100
DS 66	P	**S1**	393	M/P	77,6	10,0	12,4	0,28	0,32	0,97	44,8	17,7	2,6	4,5	9,7	0,3	1,0	-	-	-	0,7	11,3	7,1	0,3	100
DS 65	P	**S1**	700	M/W	90,6	7,8	1,6	0,35	0,11	1,00	46,7	25,7	0,7	4,3	1,7	0,3	2,0	-	-	-	-	4,0	14,7	-	100
DS 64	P	**S1**	435	M/P	84,8	9,5	5,8	0,36	0,22	1,00	43,7	24,7	1,7	5,7	4,7	0,3	0,3	-	-	-	1,0	5,7	11,0	1,3	100
DS 63	P	**S1**	440	M	75,4	11,9	12,7	0,29	0,28	0,97	42,0	17,7	2,7	6,7	10,7	1,0	0,7	-	-	-	0,3	9,7	8,3	0,3	100
DS 62	P	**S1**	520	M	83,0	8,1	8,9	0,38	0,20	1,00	42,0	25,0	1,3	4,3	7,7	1,0	1,0	-	-	-	-	6,3	11,0	0,3	100
DS 61	P	**S1**	610	P	78,4	14,1	7,5	0,33	0,06	0,83	41,7	21,0	0,7	10,7	5,0	1,0	0,3	-	-	-	1,7	0,7	17,0	0,3	100
DS 60	P	**S1**	810	M	74,7	6,1	19,2	0,46	0,19	1,00	33,3	29,7	1,0	3,7	16,0	1,0	2,3	-	-	-	0,3	6,3	6,0	0,3	100
MAX 2	V	**P2**	160	P	55,7	9,5	34,8	0,34	0,07	1,00	19,0	10,0	0,3	4,7	18,7	-	-	-	-	-	13,7	24,7	2,3	6,7	100
Inferno																									
MAX 43	S	**S2**	650	W	88,4	5,8	5,8	0,44	0,00	0,90	27,3	22,7	-	2,7	3,3	-	1,7	-	-	-	1,3	1,3	3,7	36,0	100
MAX 42	S	**S2**	570	P	93,3	1,9	4,8	0,29	0,00	1,00	23,0	9,3	-	0,7	1,7	-	0,3	-	-	-	0,7	3,0	1,7	59,7	100
MAX 41	S	**S2**	480	W	96,5	3,0	0,5	0,26	0,00	1,00	47,0	17,0	-	2,0	0,3	-	0,3	-	-	-	0,3	6,3	18,3	8,3	100
MAX 40	S	**S2**	600	W	97,2	0,6	2,2	0,58	0,00	1,00	24,3	33,3	-	-	1,3	-	0,3	-	-	-	-	4,3	30,3	6,0	100
MAX 39	S	**S2**	145	M/W	84,6	9,0	6,4	0,09	0,07	0,80	40,0	4,0	0,3	4,3	2,7	0,3	0,3	-	-	-	2,3	19,7	25,7	0,3	100
MAX 38	S	**S2**	320	M	88,3	9,1	2,5	0,26	0,00	1,00	42,7	15,3	-	5,7	1,7	-	0,3	-	-	-	-	7,0	24,3	3,0	100
MAX 37	S	**S2**	560	M/W	94,7	2,4	2,9	0,34	0,20	1,00	42,0	22,3	-	0,3	2,0	-	2,7	-	-	-	0,3	2,7	11,3	16,7	100
MAX 36	S	**S2**	710	M/W	88,8	0,0	11,2	0,45	ind.	0,93	20,3	16,7	-	-	4,3	-	0,3	-	2,7	-	-	-	0,7	55,0	100
MAX 35	S	**S2**	275	M/P	96,5	2,3	1,2	0,25	0,00	1,00	41,3	14,0	-	1,3	1,0	-	-	-	-	-	0,3	6,3	12,7	23,0	100
MAX 34	P	**S1**	670	M	78,1	2,2	19,7	0,45	0,50	0,94	25,7	21,7	0,7	0,7	11,7	0,3	0,3	-	-	-	2,7	30,0	3,7	2,7	100
MAX 33	P	**S1**	850	P	82,7	1,2	16,1	0,53	0,00	0,93	21,0	24,7	-	0,7	9,0	0,7	-	-	-	-	-	33,3	7,7	3,0	100
MAX 32	P	**S1**	1600	VP	79,2	3,6	17,3	0,49	0,00	0,97	26,7	25,3	-	2,3	11,3	-	0,3	-	-	-	0,3	17,7	5,7	10,3	100
MAX 31	V	**S1**	385	M	80,9	3,4	15,7	0,54	0,57	1,00	22,7	29,7	1,3	0,7	12,7	-	1,0	-	-	-	3,7	15,0	1,7	11,7	100
MAX 30	V	**S1**	385	M/P	75,4	4,7	19,9	0,53	0,10	0,98	24,0	28,0	0,3	3,0	14,0	-	1,0	-	-	-	-	24,7	3,7	1,3	100
MAX 29	V	**P2**	385	M/P	67,9	4,8	27,3	0,51	0,00	0,93	22,0	24,0	-	3,3	19,0	0,7	0,7	-	-	-	2,0	18,7	4,7	5,0	100
MAX 28	V	**P2**	1650	P	67,1	1,8	31,1	0,66	0,00	1,00	15,7	32,3	-	0,7	22,7	-	1,7	-	-	-	1,0	15,0	5,0	6,0	100
MAX 27	V	**P2**	385	P	64,5	2,4	33,2	0,42	0,20	0,96	25,0	19,0	0,3	1,0	23,3	1,0	0,3	0,7	-	-	1,0	22,3	0,7	5,3	100
MAX 26	V	**P1**	580	M/P	36,1	4,8	59,1	0,37	0,18	0,96	17,0	10,3	0,3	3,0	43,7	-	2,3	-	-	-	0,3	18,3	3,3	1,3	100
MAX 25	V	**P1**	1500	VP	43,7	2,8	53,5	0,34	0,00	0,97	18,0	10,7	-	2,0	37,7	0,3	2,7	-	-	0,3	1,0	21,3	2,7	3,3	100
MAX 24	V	**P1**	285	P	41,1	8,6	50,3	0,42	0,44	0,97	14,3	10,7	2,3	2,7	30,7	0,3	1,0	-	-	-	1,7	25,7	3,0	7,7	100
MAX 23	V	**P1**	190	M/P	43,2	10,1	46,7	0,41	0,29	0,97	14,3	10,0	1,7	3,7	25,7	-	1,0	-	-	-	1,3	19,7	4,7	18,0	100
Inferno bis																									
MAX 49	S	**S3***	125	M/W	79,3	14,0	6,6	0,28	0,00	1,00	23,0	9,0	-	5,3	2,7	-	0,3	-	-	-	8,0	23,3	13,0	15,3	100
MAX 48	S	**S2**	290	P	86,9	10,1	3,0	0,29	0,00	1,00	40,7	17,0	-	6,3	2,0	-	0,3	-	-	-	0,7	4,3	21,3	7,3	100
MAX 47	S	**S2**	240	M/W	90,6	9,4	0,0	0,26	0,00	ind.	30,3	10,7	-	4,3	-	-	0,7	-	-	-	-	-	14,3	39,7	100
MAX 46	S	**S2**	330	M/W	96,1	3,2	0,6	0,30	0,00	1,00	34,7	14,7	-	1,7	0,3	-	-	-	-	-	-	4,0	6,3	38,3	100
MAX 45	S	**S2**	385	M/W	97,9	2,1	0,0	0,38	0,00	ind.	38,0	23,3	-	1,3	-	-	-	-	-	-	-	3,0	11,3	23,0	100
Ca' S.Marco																									
DS 26	S	**S3***	480	M/W	91,8	8,2	0,0	0,10	0,53	ind.	50,0	5,7	2,7	2,3	-	-	-	-	2,3	-	0,3	1,3	7,0	28,3	100
DS 25	S	**S3***	500	M/W	79,3	13,9	6,7	0,35	0,17	0,86	34,7	19,0	1,7	8,0	4,7	0,7	0,7	-	-	-	0,7	6,0	19,0	5,0	100
DS 24	S	**S3***	840	M/W	96,6	2,8	0,6	0,47	0,20	1,00	29,0	26,7	0,3	0,7	0,3	-	1,7	-	-	-	1,3	4,7	4,0	31,3	100
DS 23	S	**S3***	130	M/W	77,3	10,8	11,9	0,51	0,32	0,95	20,3	22,7	2,0	4,3	7,0	1,7	0,7	-	-	-	4,7	6,3	8,0	22,3	100
DS 22	S	**S2**	620	M/W	96,2	2,7	1,1	0,47	0,60	1,00	31,3	28,0	1,0	0,7	0,7	0,3	-	-	5,7	-	0,3	6,3	1,0	24,7	100
DS 20	S	**S2**	1450	M/W	90,9	8,0	1,1	0,52	0,27	0,50	24,8	28,4	1,3	3,5	1,0	-	1,0	0,3	7,7	-	1,7	3,7	1,0	25,8	100
DS 19	S	**S2**	880	W	87,8	8,0	4,3	0,37	0,80	0,75	33,0	19,3	4,0	1,0	2,3	2,3	0,7	-	2,0	-	3,0	7,3	2,7	22,3	100
DS 16	S	**S2**	555	M/W	90,5	9,0	0,5	0,40	0,06	0,00	33,3	22,3	0,3	5,3	-	1,3	0,3	-	0,7	-	3,7	4,0	3,0	25,7	100
DS 14	S	**S2**	710	W	86,4	11,4	2,2	0,43	0,57	1,00	29,3	22,0	3,3	3,0	1,3	2,0	0,3	-	3,3	-	0,7	1,3	0,7	32,7	100
DS 13	S	**S2**	660	W	89,0	9,0	1,9	0,48	0,05	0,75	31,3	30,0	0,3	6,0	1,0	0,3	1,0	-	-	-	-	6,3	17,7	6,0	100
DS 7	V	**P2**	875	M	65,8	13,8	20,4	0,60	0,39	0,89	16,7	28,7	4,0	6,0	15,3	2,7	1,7	-	-	-	0,3	10,0	3,3	11,3	100
DS 6	V	**P2**	900	M	70,3	12,4	17,2	0,52	0,42	0,94	21,7	24,0	3,3	4,3	11,0	2,7	2,7	-	-	-	1,0	8,7	7,3	13,3	100
DS 5	V	**P2**	925	M/P	65,7	10,2	24,1	0,59	0,17	0,97	19,9	28,6	0,6	6,3	13,9	2,7	1,0	-	-	-	1,0	15,2	10,3	0,3	100
DS 4	V	**P2**	870	M	65,0	8,4	26,6	0,56	0,35	0,96	20,7	28,0	2,0	4,3	15,7	2,0	1,7	-	-	-	-	13,0	10,3	2,3	100
DS 3	V	**P2**	1000	M	70,7	6,9	22,4	0,62	0,17	0,97	19,5	37,1	1,0	5,0	21,5	1,6	-	-	-	-	1,0	10,7	2,6	-	100
DS 2	V	**P2**	820	M	65,8	3,9	30,2	0,56	0,00	0,92	20,7	30,3	-	3,0	21,3	3,0	0,7	0,3	-	-	1,7	17,3	1,3	0,3	100
DS 1	V	**P2**	1200	M	76,4	2,6	21,0	0,58	0,00	0,92	21,0	33,7	-	2,0	16,3	3,3	-	-	-	-	-	8,0	4,0	11,7	100

Tab. 2 - Point-counting data for the 184 studied Permo-Anisian sandstones. Unit = lithostratigraphic units (V = Verrucano Lombardo; P = Prato Solaro Member; S = middle-upper part of the Servino Formation; A = Silty Member of the Angolo Limestone; B = Bellano Formation; M = Valsassina Member; D = Dolomitic Albiga Member); Pf = petrofacies (see text); GSZ = grain size (in μm); SRT = sorting (P = poor; M = moderate; W = well); Q = quartz (Qs = monocrystalline; Qp, C = polycristalline); F = Feldspar (Pl, P = plagioclase; Af = Alkali feldspars including chessboard albite); L = fine-grained "aphanitic" lithics; RF = fine to coarse-grained rock fragments (V = volcanic; M = metamorphic; P = plutonic to hypabyssal; A = arenaceous); I = intrabasinal grains (C = carbonate; NC = non-carbonate); Acc = heavy minerals and micas; Mat = matrix, epimatrix and pseudomatrix; Cem = "compatible" syntaxial cements; Aut = authigenic minerals and carbonate replacements; TOT = total.

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