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CONSIGLIO NAZIONALE DELLE RICERCHE

ISTITUTO PER LA GENESI E L'ECOLOGIA DEL SUOLO - FIRENZE

# NORTHERN ASSO RIVER BASIN (SIENA - ITALY). ANALYSIS OF LINEARS - LANDFORMS - GEOLOGY RELATIONSHIPS AND ANTHROPIC EFFECTS IN THE PERIOD 1976 - 1994

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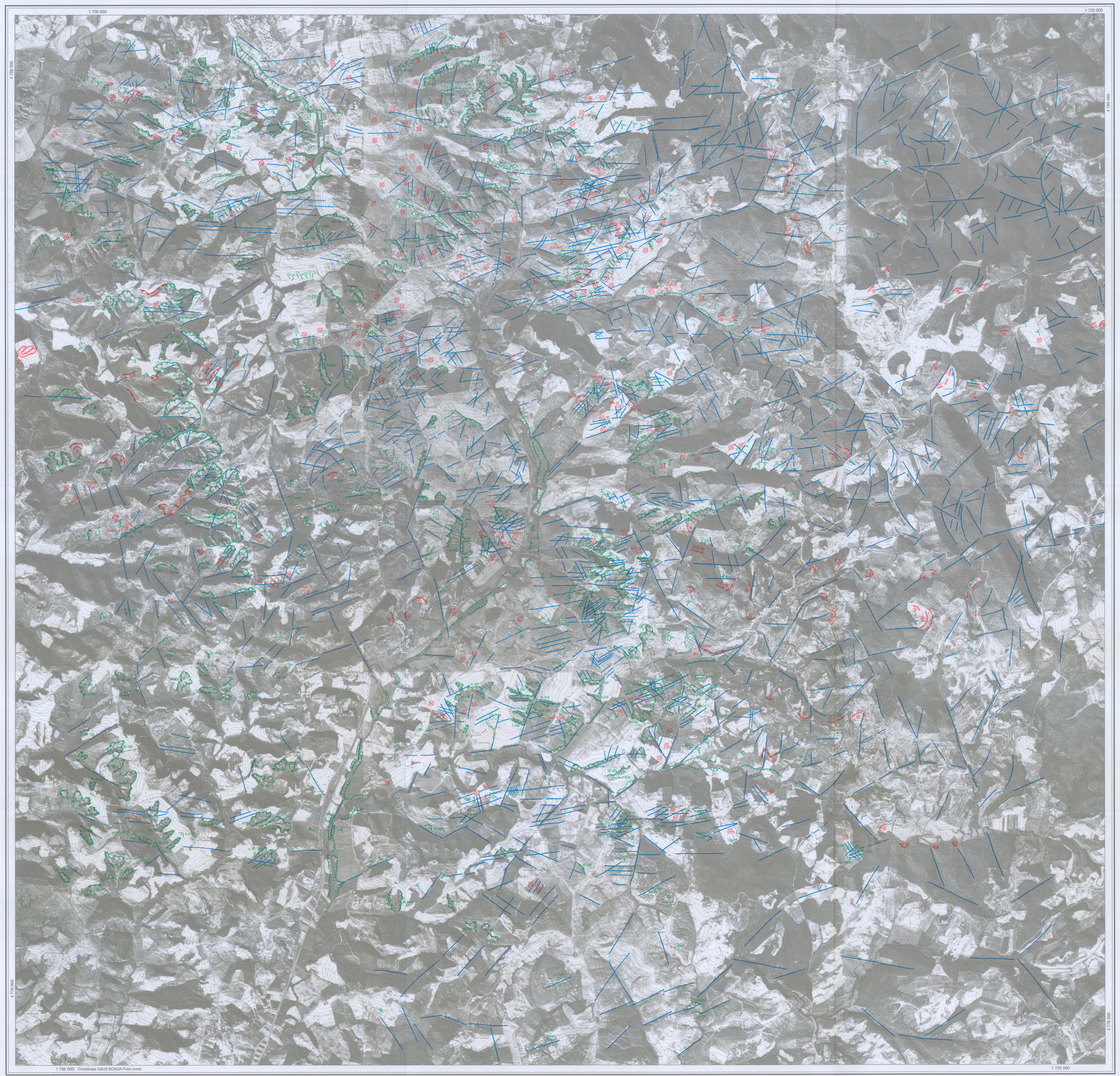
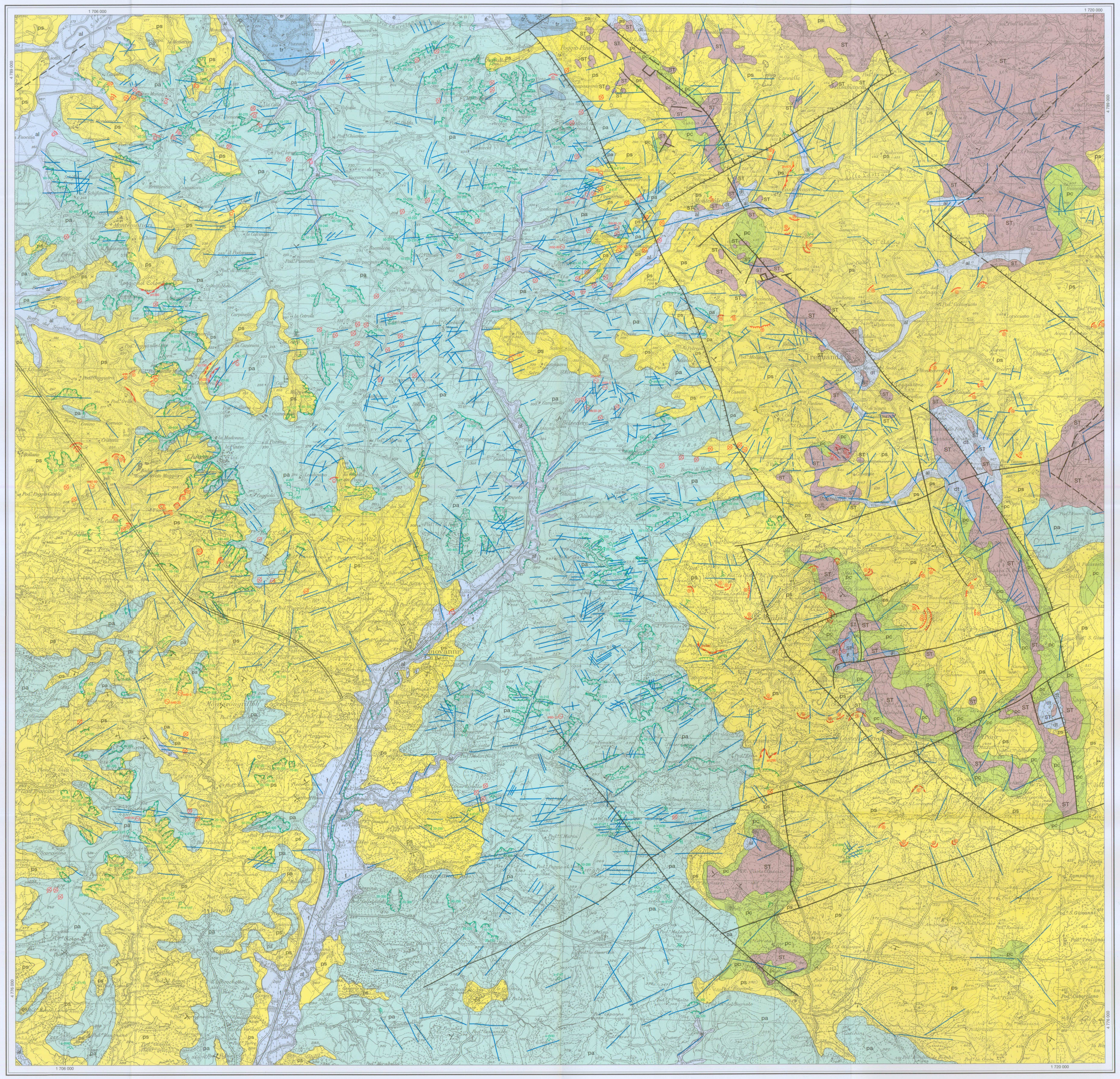
Scale 1: 25 000

## LINEARS, LANDFORMS AND ANTHROPIC EFFECTS IN 1976




## LINEARS, LANDFORMS, GEOLOGY AND ANTHROPIC EFFECTS IN 1994




## GEOLOGY

Geologic map according to the Servizio Geologico d'Italia, Foglio 121- Montepulciano, scale 1:100.000, map *(after Jacobacci & Malatesta, 1968)*. Stratigraphy: *after Losacco (1963); Jacobacci et alii (1969); Boccaletti et alii (1987); Berti et alii (1992)*.

- **ST** Tuscan Series (*upper Trias – Oligocene*).
- **F** Flysch facies (*Oligocene-Miocene*)
- **pa** Marine clays and sandy clays with conglomerate lenses (*Early - Middle Pliocene*).
- **ps** Sand and clayey sands with molluscs, brachipods, and crustacea, with lenses or layers of conglomerate or lignite, or silty clay or clay (*Middle Pliocene*). Olistostromes of mesozoic limestones and dolomitic limestones are sometimes present.
- **pc** Polygenetic conglomerates, with several relationships with the other Pliocene deposits.
- **tr** Travertines (*Pleistocene – Holocene*).
- **f** Stream terrace (*Holocene*).
- **e** Eluvial and colluvial deposits (*Holocene*).
- **al** Alluvial deposits (*Holocene*).
- **dt** Slope-debris (*Holocene*).

- dip
- normal fault
- normal buried fault
- anticline axis
- **Linear:** mainly recognized by aero-photo interpretation (photo scale: about 1:13000)

## LANDFORMS

(Landforms classification according with main morphogenetic processes)

### Erosional processes:

**Biancana** (B): a dome-shaped landform, usually present in clusters on hill slopes not steeper than 25%. Generally lower than 20 m, with a sub-horizontal pediment (or erosion-deposition glacis - *Castiglioni, 1979, Torri et alii, 1994*). This landform usually develops in clay sediments (*Guasparri, 1978; Colica & Guasparri, 1990; Guasparri, 1993; Busoni & Colica, 2001*) but can also be found as clay lenses in **ps**. The dome has asymmetrical slopes, with the southern one steeper than the northern one. The landform can be bare, half vegetated (northern slope) or fully vegetated; in these two latter cases soils (from Enti- to Inceptisoils) are present. Rhomboidal nets of joints are related with the development of biancana; net joints directions may show linears directions (*Colica & Guasparri, 1990; Brondi et alii, 1992; Benvegnu et alii, 1993*).

position on the slope:
top a
mid m
foot b
tipology
dome (after Calzolari, 1998) d
vegetated V
bare n
vegetated only on a slope 1/2 V
orthogonal direction to the main axis (°)
if the landform is circular the orthogonal direction to the main axis cannot be determined T

**Runoff surface:** surface created by the part of the rainfall that flows off, in non-concentrated form or in temporary, very shallow, channels (*Bergsma et alii, 1996*).

**Gully:** an incised channel or miniature valley cut by concentrated but intermittent runoff. It is deep enough to interfere with, and not to be obliterated by, normal tillage operations (*Bergsma et alii, 1996*).

**Shallow gully:** gully, not deeper and/or wider than 0.50 m, usually developed on sub-horizontal surfaces at the head of a calanco (*Busoni et alii, 1998*).

**Fluvial terrace scarp:** the landform derives from the cut of old fluvial surfaces, graded to the present base level (*Castiglioni, 1979; Soil Survey Staff, NRCS, 2001*).

**Calanco potential area** (CPA, *Busoni et alii, 1998*): morphologically complex hill slope, generally steeper than 25%. It may represent either a transitional stage from a grazed or a cultivated area to a calanco; either a transition from a calanco area to a permanent, vegetated one. In the first case, features of erosional incipient processes to a calanco are evident; in the second case the calanco features are still recognizable, notwithstanding the presence of vegetation.

### Erosional and gravitational processes (values in meters were retrieved on the 1:10000 base map)

**Calanco** (C): small drainage basin, formed by small talwegs separated by narrow interfluves (more or less sharp ridges with slope angles depending on the physical and mechanical characteristics of the bedrock (*Rodolfi & Frascati, 1979; Mazzanti & Rodolfi, 1988*). The landform develops on steep slopes (> 25%), mainly on clayey sediments, or clayey sediments stratified with textures coarser than clay (*Colica, 1992, 2000; Busoni & Colica, 2001*); it is generally more than 20 m high.
If the calanco headcut is almost linear and the calanco is asymmetrical with respect to the main hydrographic axis:
heigth (meters)
width (meters)
If the calanco headcut is arcuate and the calanco is symmetrical with respect to the main hydrographic axis:
heigth (meters)
length is the distance from head to the chord linking the its lowest points (meters)

### Gravitational processes (values in meters were retrieved on the 1:10000 base map)

**Shallow seated gravitational deformation** (SSGD, *Busoni et alii, 1998*): elliptical, convex landform developed in **pa**, intergraded or not by sand layers, on hill slopes less steep than 20%; its main axis is shorter than 60 m but longer than that of biancane. Generally it is in clusters. It does not seem to be evidently related to a crown. Rhomboidal joint nets are related with the development of **SSGD** (*Colica & Guasparri, 1990*). Net joints directions may show linears directions.

*position on the slope*
top a
mid m
foot b
extention of the main axis (meters)
orthogonal direction to the main axis (°)

**Rock fall** (Fcr): it develops in **ps, ps-pc, ST** and in sand lenses present in **pa**. It is characterized by a vertical or sub-vertical scarp. The scarp may coincide with joints.

**Earthflow** (Fco): landform characterized by downslope translation of soil and weathered rock over a discrete basal shear surface within well defined lateral boundaries (*Soil Survey Staff, NRCS, 2001*). The crown may coincide with joints. This convex landform usually has dimensions larger than those of the **SSGD**. It develops in clay sediments, with or without sand interlayers.

**Balza** (Bz): nearly vertical cliff, several meters high, mainly developed in arenites and rudites.
linear l
arcuate ar
chord length (meters).

### Anthropic processes

**Levelled biancana** (Bl, *Busoni et alii, 1998*): the landform has been levelled because of the agricultural use of the slope. Its elliptical, or circular, base section is still visible.

**Levelled shallow seated gravitational deformation** (SSGDl, *Busoni et alii, 1998*): the landform has been levelled because of agricultural use. Its elliptical base section is still visible.

## NOTE

Landscapes change with time as a consequence of environmental state factor, anthropic included, changes. In fragile environments the changing of anthropic pressure, at present coincident with climate change, on landscape can be terrific and give origin to strong environmental degradation. Pressures on meta-stable state factors can trigger degradational processes to catastrophes. Remediation social and monetary costs can go very high; often not achieving the final aims. The knowledge of how and how much an environment changed in a specific time period is of paramount importance to build up scenarios and trends for the future. Most important is to control how anthropic pressures can lead to an increase in land degradation as a consequence of the influences of over-stressed landforms on hillslopes and watersheds hydraulics. Linear tectonic features are to be taken into account to define their influence on the evolution of a landscape and its landforms. The present maps highlight the changes occurred in the period 1976-1994 in a study area of central Italy. Linears and landforms (see Legend) were investigated. The analysis was carried on by aero-photo interpretation and field controls, taking into account linears, landforms, geology. Geology was used as first discriminant in the analysis of linears and landforms features. Data were reported on a 1:10000 scale base map and analysed on 1 km$^2$ base. Several linears were found to define directional trends showing the main regional faults directions: N37°, N162°, N145°, N90°, N-S; these trends are called "main trends".

Tab. 1: Number of "main trends" linears relationship with geology (symbols as in legend).

| Geology | Main Trends (37°) | (162°) | (145°) | (90°) | (0°) |
|---|---|---|---|---|---|
| pa | 15 | 13 | 26 | 121 | 9 |
| ps | 5 | 7 | 3 | 9 | |
| ps pc | 2 | | | 1 | |
| ps ST | 9 | | | 5 | |
| ps pa | | 1 | | 1 | |
| ST | 5 | 4 | 3 | 21 | |
| ST ps | | | | 1 | |
| ST ps pc | | | | 5 | |
| al | | | | 1 | |
| total | 36 | 25 | 32 | 165 | 9 |

Some other linears show directions different from the "main trends" ones: these linears are called "local linears".
Different "linears landscapes" were found as a function of "local linears" density (= nr of linears/km$^2$), linears directions (°) and geology.

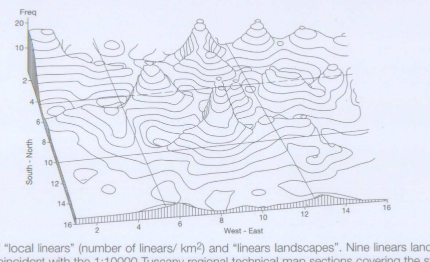



Fig. 1: Frequencies of "local linears" (number of linears/ km$^2$) and "linears landscapes". Nine linears landscape (fig. 1) were recognized, roughly coincident with the 1:10000 Tuscany regional technical map sections covering the study area (NW: Asciano; N: S. Gimignanello; NE: Sez. 298130; W: Chiusure; Central: S. Giovanni d'Asso; E: Trequanda; SW: Montegriffoli; S: Castelmuzio; SE: Montefollonico).

Tab. 2: Local linears directional analysis in the nine "linears landscapes". Rayleigh's uniformity test calculates the probability **p** of the null hypothesis that the data are distributed in a uniform manner. A probability less than your chosen significance level (0.05) indicates that the data are not distributed uniformly and that they show evidence of a preferred direction.

| "Linears landscapes" | NW | N | NE | W | C | E | SW | S | SE |
|---|---|---|---|---|---|---|---|---|---|
| Observations | 110 | 220 | 74 | 131 | 378 | 133 | 33 | 214 | 31 |
| Mean vector (μ) | 65.42° | 59.36° | 141.79° | 49.79° | 63.34° | 48.80° | 83.72° | 69.47° | 55.70° |
| Length of mean vector (r) | 0.22 | 0.41 | 0.08 | 0.34 | 0.36 | 0.1 | 0.23 | 0.26 | 0.24 |
| Concentration | 0.45 | 0.9 | 0.17 | 0.72 | 0.77 | 0.19 | 0.47 | 0.55 | 0.5 |
| Circular variance | 0.78 | 0.59 | 0.92 | 0.66 | 0.64 | 0.9 | 0.77 | 0.74 | 0.76 |
| Circular standard deviation | 99.84° | 76.47° | 127.86° | 84.38° | 82.08° | 124.13° | 98.51° | 93.65° | 96.58° |
| Standard error of mean | 17.41° | 6.36° | 56.71° | 10.16° | 5.62° | 36.63° | 30.51° | 10.35° | 29.67° |
| Rayleigh test of uniformity (p) | 0.01 | 0 | 0.6 | 0 | 0 | 0.3 | 0.18 | 0 | 0.16 |

Tab. 3: Watson's test probability **p** matrix on "linears landscapes" directions. The **p** value printed for each test is the probability associated with the null hypothesis that the two mean angles are equal. If this probability is less than the chosen significance level (0.05), then the null hypothesis can be rejected in favour of the hypothesis that the two means are different (red italics bold values) .

| | NW | N | NE | W | C | E | S | SW | SE |
|---|---|---|---|---|---|---|---|---|---|
| NW | | 0.3 | 0 | 0 | 0.7 | 0.1 | 0.5 | 0.11 | 0.4 |
| N | | | 0 | 0.1 | 0.3 | 0.2 | 0 | 0.02 | 0.7 |
| NE | | | | 0 | 0 | 0 | 0 | 0 | 0 |
| W | | | | | 0 | 0.9 | 0 | 0 | 0.6 |
| C | | | | | | 0.1 | 0.2 | 0.04 | 0.4 |
| E | | | | | | | 0 | 0 | 0.6 |
| S | | | | | | | | 0.17 | 0.2 |
| SW | | | | | | | | | 0.1 |
| SE | | | | | | | | | |

Tab. 4: number of "local linears" and their percentage as function of geology, in each landscape (symbols as in legend).

| | | |
|---|---|---|
| NW linears: 110<br>pa: 97.3; ps: 0.9; tr: 1.8 | N linears: 220<br>pa: 63.6; ps: 34.1; ST: 0.9; tr: 0.5; al: 0.9 | NE linears: 74<br>pa: 1.4; ps: 98.6 |
| W linears 131<br>pa: 99.2; ps: 0.0; ps-pc: 0.8 | Central linears: 378<br>pa: 80.7; ps: 0.3; ST: 19.0 | E linears: 133<br>pa: 0.0; ps: 0.0; ST: 100.0 |
| SW linears: 33<br>pa: 87.9; ps: 0.0; al: 12.1 | S linears: 214<br>pa: 92.0; ps: 5.0; al: 3.0 | SE linears: 31<br>pa: 0.0; ps: 0.0; ps-pc: 100.0 |

Tab. 5: landforms relationships with geology (symbols as in legend).

| Landforms | Geology pa | ps | ps- pc | ST |
|---|---|---|---|---|
| C | * | | | |
| CPA | * | | | |
| B - Bl | * | | | |
| SSGD - SSGDl | * | | | |
| Fco | * | | | |
| Fcr | | * | * | * |
| Bz | | * | | |

Tab. 6: anthropic effect. Variations in landforms presence in the period 1976 – 1994, and their relationships with linears. It is to be considered that most of the differences are effects of anthropic pressures on the environment. Decrease in levelled landforms must be seen as obliteration of their base sections by land use: these cannot be recognised neither by photo-interpretation, nor by field survey; the same should be held for their relationships with linears (symbols as in legend).

| | 1976 Total nr of landforms | Related to linears Nr | % | Not related to linears Nr | % | 1994 Total nr of landforms | Related to linears Nr | % | Not related to linears Nr | % | Differences between totals Abs. value | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C | 309 | 231 | 74.8 | 78 | 25.2 | 201 | 151 | 75.1 | 50 | 24.9 | -108 | -34.9 |
| CPA | 54 | 40 | 74.1 | 14 | 25.9 | 57 | 36 | 63.2 | 21 | 36.8 | +3 | +5.5 |
| B | 54 | 38 | 70.4 | 16 | 29.6 | 40 | 24 | 60.0 | 16 | 40.0 | -14 | -25.9 |
| Bl | 57 | 26 | 45.6 | 31 | 54.4 | 18 | 18 | 100 | - | - | -39 | -68.4 |
| SSGD | 30 | 30 | 100 | - | - | 15 | 7 | 46.6 | 8 | 53.4 | -15 | -50 |
| SSGDl | 156 | 85 | 54.5 | 71 | 45.5 | 71 | 47 | 66.2 | 24 | 33.8 | -85 | -54.5 |
| Fco | 27 | 19 | 70.4 | 8 | 29.6 | 19 | 19 | 100 | - | - | -8 | -29.6 |
| Fcr | 87 | 55 | 63.2 | 32 | 36.8 | 65 | 52 | 80.0 | 13 | 20.0 | -22 | -25.3 |
| Bz | 6 | 4 | 66.6 | 2 | 33.4 | 6 | 4 | 66.6 | 2 | 33.4 | 0 | 0 |

### Typology of the relationships between linears and landform.

Linears can relate to landforms in several ways. The following relationships were defined and shown in Tables 5 and 6:
l - linears limit the landform (mainly C and CPA);
ai - linears coincide with the main hydrographic axis representing the base level for tributaries which control landforms evolution; indirect effect (mainly C);
l-head - linears coincide with the landform head (mainly C and CPA);
ad - linears coincide with main hydrographic axis; direct effect (mainly C and CPA);
t - linears cut the landform, not coinciding with hydrographic axis (mainly C and CPA);
d - linears partecipate to the net in which the landform develops (mainly B, Bl and SSGD, SSGDl);
p - linears are parallel to the crown of the landform (mainly Fcr, usually in ps, pc, ST);
inter - the landform interrupts the linear;
al - linears are aligned with the landform (mainly Fcr and Bz, usually in ps, pc, ST).

Tab. 7: typology percentage of the relationships between linears and landform in **pa** (symbols as in legend).

| Landform | l | ai | l-head | ad | t | d |
|---|---|---|---|---|---|---|
| C | 24.3 | 15.8 | 4.5 | 10.2 | 45.2 | - |
| CPA | 8.8 | - | 8.8 | 52.9 | 29.5 | |
| B - Bl | - | - | - | - | - | 100 |
| SSGD - SSGDl | - | - | - | - | - | 100 |
| Fco | - | - | - | - | 100 | |

Tab. 8: typology percentage of the relationships between linears and landform in **ps, pc, st** (symbols as in legend).

| Landform | l | ad | t | p | inter | al |
|---|---|---|---|---|---|---|
| Fcr | 14.3 | 28.6 | 14.3 | 28.6 | 7.1 | 7.1 |
| Bz | - | - | 50 | - | 25 | 25 |

Note to tables: data in the tables refer to real values of the different variables analized, as counted on the working map at the 1:10000 scale, on which photo-interpretation data were reported. The presented maps were done by the reduction of the original to the 1.25000 scale; some of the original features were deleted to keep clearness in the readability of the maps, always trying not to betray the aims of study (comparison between landforms in the period 1976-1994), so that data in the tables slightly differ from map data.

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