Lower Miocene volcaniclastic assembly of the Bisciaro Formation: Northern Apennines, Italy

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INTRODUCTION

This project investigates several locations of the Lower Miocene (Aquitanian to Burdigalian) Bisciaro Formation in the Umbria-Marche Apennines if North central Italy. The upper and lower boundary of the studied interval are easily identified and correlated using regional marker ash beds. The volcaniclastic deposits at each location do not exhibit any distinctive characteristics that would enable the correlation of single ash layers between field sites. Amorosi *et al.* (1994) attempted to correlate single ash layers of the identical stratigraphic interval at 17 locations without success. The numerous sections studied by Amorosi *et al.* (1994) were more closely spaced than the locations in this study, yet they also concluded "single layers cannot be traced from one place to another".

Geochemical studies by Balogh *et al.* (1993), Amorosi *et al.* (1994), and Amorosi (1994) combined individual ash layers in this interval as a single phase of volcanic activity and fitted the results into a larger perspective of the geodynamic evolution. The present study attempts to use detailed geochemical data and stratigraphic relationships of individual ash layers at four locations toward a more detailed study of the stratigraphy focusing on the following goals:

- possible mechanism of emplacement of individual ash layers
- detailed analysis of stratigraphic changes in chemical composition caused by the emplacement or subsequent weathering processes
- explanation of the geochemical changes as part of the larger evolution of the Umbria-Marche basin

GEOLOGICAL SETTING

The carbonate sequence of the northern Apennines contains a continuous record of tectonic and sedimentary evolution of a deepwater marine basin from Early Jurassic to late Tertiary. During the Tertiary, the northern Apennines of Italy functioned as a quiet depositional marine basin for fine-grained volcanic ashfalls from distant explosive volcanism accompanying the Alpine/Apennine orogenesis (Montanari, *et al.*, 1994). At this time, the Umbria-Marche basin was dominated by continuous pelagic sedimentation and was interrupted only during synorogenic turbiditic sedimentation (Montanari, *et al.*, 1994).

STRATIGRAPHY

The Lower Miocene Bisciaro Formation is characterized by prevailing calcareous marly deposits, rich in volcaniclastic material. Stratigraphic relationships for this study have been constructed using two well-known and easily recognizable ash layers as upper and lower boundaries. The lower boundary of the studied interval is the 21.3 Ma (Montanari, *et al.*, 1994) "Livello Raffaello", a regional bentonite marker-bed representing the first occurrence of Miocene calk-alkaline volcanism in the Umbria-Marche basin. This marker bed corresponds to the base of the Bisciaro Formation.. The upper boundary is in the middle of the Bisciaro Formation at the distinctive 19.7 Ma (Montanari, *et al.*, 1994) "Mega-P". The "Mega-P" comprises a thick stack of volcanic material deposited as numerous distinct sedimentary episodes (Amorosi *et al.*, 1994). This study examines the detailed stratigraphy between the "Livello Raffaello" and the first appearance of the "Mega-P", a thickness that ranges from 4.5-14 meters at the four sections examined.

Many of the volcaniclastic beds have sharp lower boundaries that grade upwards (Amorosi *et al.*, 1994), have a lenticular shape of many beds, and show strong variation in number and thickness of layers at each location. These layer characteristics suggest ash sedimentation from decelerating turbidity currents. The volcaniclastic material in this interval was not deposited due to fall mechanisms, but is hypothesized to have undergone density current transport and deposition after the original eruptive event (Amorosi *et al.*, 1994). Dark gray layers of coarse grained material are inferred to reflect a relatively dense flow and layers without coarse material would represent a dilute current (Amorosi *et al.*, 1994). These observations finding no distinctive lateral trend suggests that the paleotopography of the Bisciaro Basin must have been irregular for deposition of ash layer in lenses with few blanket-type layers (Amorosi *et al.*, 1994).

METHODS

Field work. Four locations were chosen where the lower part the Bisciaro Formation crops out; Castreccioni, Tarugo, Contessa, and Poggio di Ancona (*See Figure 1*). A detailed stratigraphy at each field location was the basis for sampling each bed which appeared to contain a concentration of volcanic material.

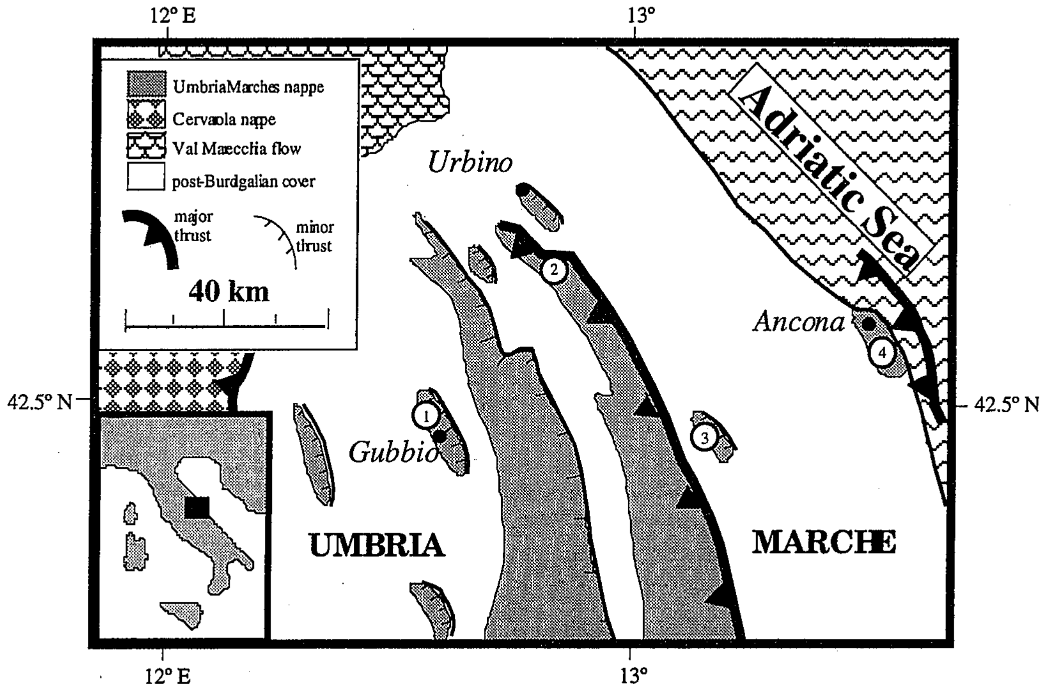

Figure 1. A simplified geologic map of the Northeastern Apennines with the locations of field sites in the Bisciaro Formation. 1) Contessa, 2) Tarugo , 3) Castreccioni , 4) Poggio di Ancona

Elimination of limestone. Volcanic material is well intercalated with the marly limestones characteristic of this formation. The limestone was eliminated by crushing the samples and digesting with 10% HCl. The samples were weighed before and after the limestone was eliminated to measure the amount of limestone in each sample.

Geochemical Analysis. Major and trace element geochemistry was completed using standard x-ray fluorescence of anhydrous samples. Concentration of elements will be plotted in stratigraphic sequence to show the variability of the geochemical components at eahc site.

VOLCANICLASTIC CHEMISTRY

It has already been determined (Balogh *et al.*, 1993, Amorosi *et al.* 1994) that the volcaniclastic material is likely to have been deposited during a secondary phase of sedimentation. During this phase the original ash was likely redeposited as a turbidity current. We can assume the volcanics from this stratigraphic interval were from a single phase of volcanism (Balogh *et al.*, 1993), thus implying that the composition of volcanic material would remain relatively constant. This leads to the conclusion that changes of composition in these volcaniclastic deposits must result from alteration of the original composition through sedimentation or chemical weathering.

Relative amounts of enrichment/depletion may be caused by depositional processes or indicate the magnitude of chemical weathering experienced at each location. For each interval, the relative amount of chemical enrichment/depletion also be determined. Quantities of certain elements at each locations were normalized to the element concentration of the Livello Raffaello at that site to allow plotting of the order of magnitude of relative change within each section.

OBSERVATIONS

The analytical data indicate two patterns of geochemical variation. The overall enrichment/depletion of certain elements at each field location indicates a regional geographic pattern. There are two locations at which all elements are relative enriched, Poggio di Ancona and Contessa, as compared to two locations with relative depletion, Tarugo and Castreccioni (*See Table 1*).

ENRICHED LOCATIONS

Sample	K2O	Rb	Y	V	Cr	U
Poggio di Ancona	1.65	69.70	25	108.90	108	5.50
Poggio di Ancona	1.67	76.70	18	117.10	101	3.10
Poggio di Ancona	2.09	82.00	16	166.30	41	3.10
POG MEAN	***1.81***	***76.13***	***20***	***130.7***	***83***	***3.90***
STD Dev	*0.25*	*6.17*	*5*	*31.04*	*37*	*1.39*

Sample	K2O	Rb	Y	V	Cr	U
Contessa	1.16	57.60	8	80.00	81	1.10
Contessa		85.80	31	61.60	63	4.20
Contessa	2.09	85.20	33	63.30	61	4.70
CON MEAN	***1.62***	***76.20***	***24***	***68.30***	***68***	***3.33***
STD Dev	*0.65*	*16.11*	*14*	*10.17*	*11*	*1.95*

DEPLETED LOCATIONS

Sample	K2O	Rb	Y	V	Cr	U
Tarugo	0.43	19.20	3	17.50	12	0.80
Tarugo		18.30	3	15.70	11	1.70
Tarugo	0.43	17.50	4	9.70	22	0.20
TAR MEAN	***0.43***	***18.33***	***3***	***14.30***	***15***	***0.90***
STD Dev	*0.00*	*0.85*	*1*	*4.08*	*6*	*0.75*

Sample	K2O	Rb	Y	V	Cr	U
Castreccioni	0.16	7.20	2	14.60	13	1.10
Castreccioni	0.14	5.00	2	15.52	13	0.20
Castreccioni	0.16	5.00	2	15.60	14	0.00
CST MEAN	***0.15***	***5.73***	***2***	***15.24***	***14***	***0.43***
STD Dev	*0.21*	*7.84*	*1*	*5.40*	*6*	*0.54*

Table 1. Concentration of selected elements in Livello Raffaello at each location. Notice the higher concentration of elements in the enriched locations and the lower concentration of elements in the depleted locations. This variation must be a result of transport and/or chemical weathering of the original volcanic material. (K_2O is in percent, Rb, Y, V, Cr, U are all in parts per million)

Overprinted on the two populations of regional enrichment/depletion is a local enrichment relative to the composition of the ash at the base of each section at that location. (See Graph 1a-d). In each interval, the relative composition appears to cycle from the composition of the base to an enriched concentration and then returns to the approximate composition of the base (See Graph 1a-c). The concentrations of elements at Poggio di Ancona act somewhat differently. The relative enrichment at Poggio di Ancona is much less than at the other sections and the concentration of elements seems cycle to to include a small cycle of element depletion (See Graph 1d). The Contessa section is topped by a tectonic boundary that does not enable the full stratigraphic interval to be viewed.

Also, the elements Rb and Y will normally vary in opposite direction for magmatic processes (Mertzman, *per. comm.*), but each of the studied intervals, these elements show parallel variation for unknown reasons.

FUTURE WORK

The enrichment/depletion from one location to the next must result from a larger mechanism than that causing the local or on-site variation of individual ash beds. Future work will focus on creating a model attempting to explain the two processes causing geochemical variation, both regionally and locally. To develop this model, a better understanding of the transport and/or weathering processes will be needed. Heavy mineral separation will allow the level the corrosion and selective destruction to be determined for minerals that are likely to contain the diagnostic trace elements from bed to bed and site to site. Additional trace element data can be collected through Inductively Coupled Plasma analysis to provide data on additonal elements that may show characteristic enrichment/depletion.

The cause of the geochemical relationships exhibited at each field site, individually and collectively, remains an enigma. This study has shown that variations are systematic fingerprints of an underlying process or processes. Identifying the fingerprint will provide new detailed information about the development of the Umbria-Marche basin during the Miocene.

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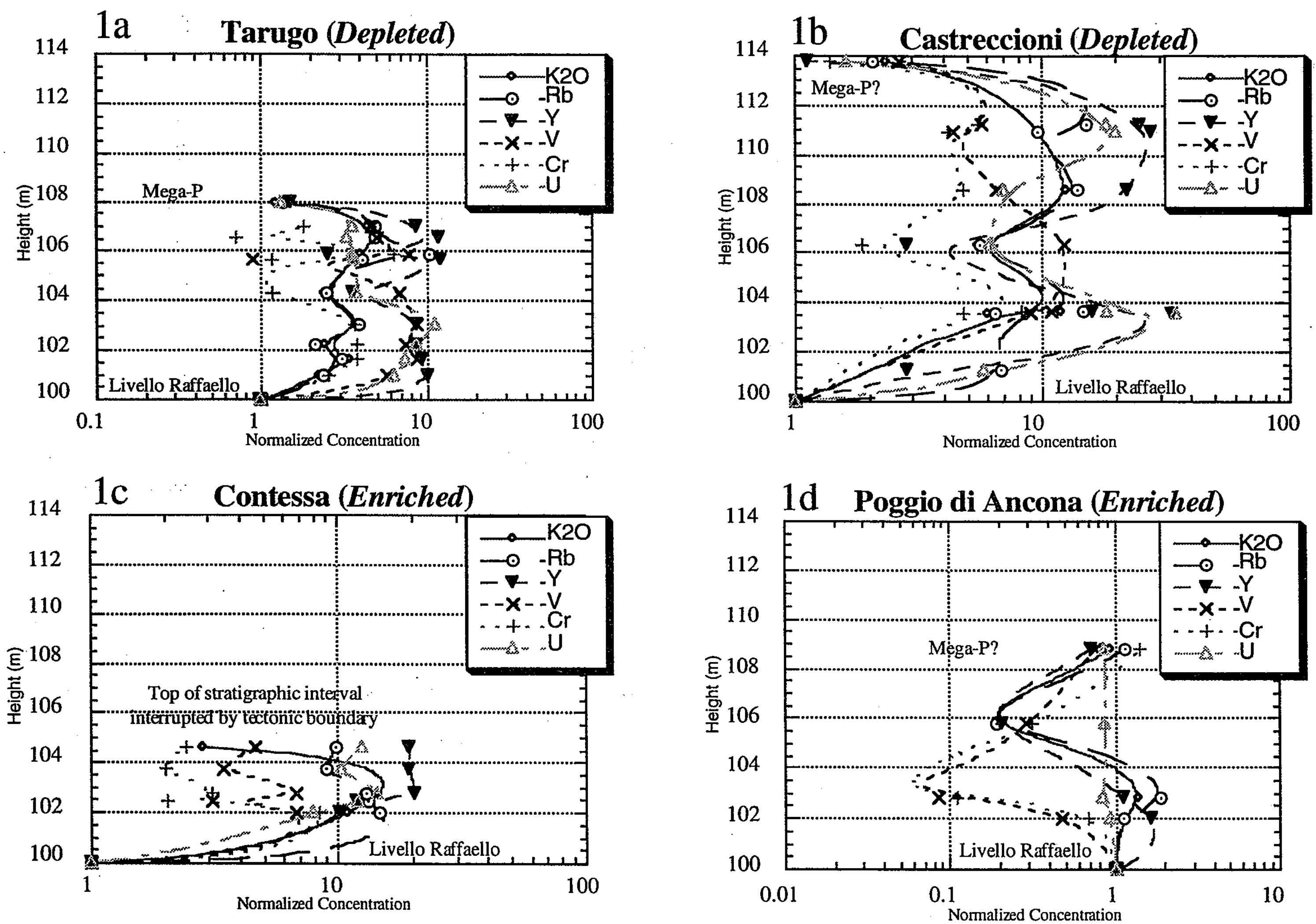

Graph 1 a-d. Local enrichment of stratigraphy relative to base of each section, Livello Rafaello. Notice that the relative concentrations appear to cycle from the composition of the base to an enriched composition then returning to the approximate composition of the base.