Comparison of Tertiary Graywacke Sequences in the Northern Apennines and some Geodynamical and Palaeogeological Implications

by

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A stage of flysch sedimentation is usually associated with the orogenetic cycle of geosynclines. This stage is usually interpreted as a sign of strong tectonic activity of the underground. The formation of the molasse sediments then completes the orogenetic cycle. The flysch sediments, in contrast to the post-orogenetic molasse, are syn-orogenetic. Flysch and molasse sediments can be found in almost all mountain ranges of the alpine-mediterranean type.

A classical region for the studies on syn-orogenetic flysch sedimentation are the Northern Apennines. In this area we find several kilometer thick graywacke series of the Oligocene and Miocene which were all involved in the mountain-building processes.

The oligocene-miocene turbiditic graywacke series of the Northern Apennines must be attributed according to their tectonic pattern to different tectonic units which now overlay each other in form of nappes. In essence, we are concerned with the following complexes (from the internal to the external parts of the mountain range) :

Ligurides : Aveto-Petrignacola-Senario-Sandstones;

Tuscanides : Macigno, partly metamorphic in the Apuan Alps;

Modino-Cervarola-Unit : Modino-Sandstones and Bobbio-Pracchiola-Cervarola-Falterona-Sandstones;

Umbro-Markides : Formazione marnoso-arenacea.

(The individual graywacke complexes reach thicknesses of several thousand meters.)

Many attempts have been made in the past to attribute these graywacke sequences to a homogeneous sedimentation process which is supposed to be controlled by orogenetic events.

Our studies are based on the assumption that the individual graywacke complexes can be attributed to different basins of sedimentation which produce the following scheme (Fig. 1) (arranged from internal to external). The individual series are older in the internal parts and become younger towards the external zones; however in that way, that the next series towards the outside begins before the previous series has completed sedimentation. There is no stratigraphic succession of the entire series (except for the Modino- and Cervarola-Sandstones). That means that all studied complexes were deposited in separate troughs.

The occurence of olisthostromes in the individual graywacke series as well as the presence of fluxoturbidites and thick conglomerates (Aveto-Sandstones) composed of crystalline material, indicate at least the occasional emersion of crystalline ridges between the troughs. These hypothetical ridges would provide an explanation for the much discussed question of the origin of the clastic material which produce a total of about 8 to 10 km thickness.

Rapp. Comm. int. Mer Médit., **23**, 4a, pp. 79-82, 3 figs., (1975).

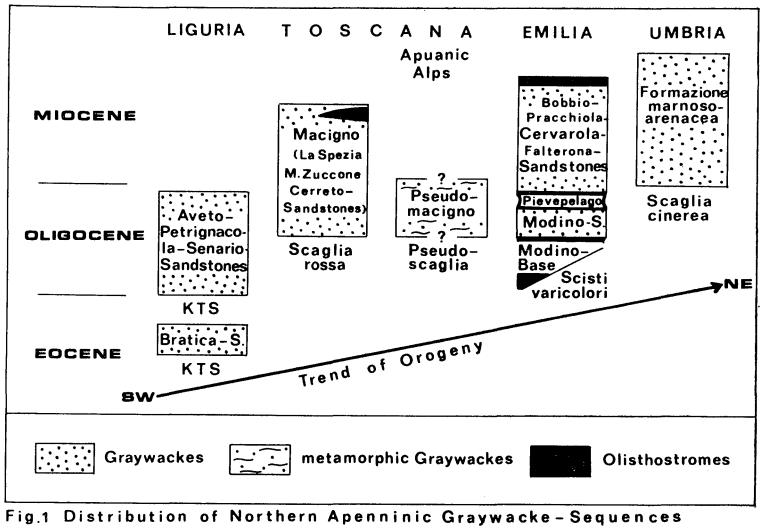

Fig.1 Distribution of Northern Apenninic Graywacke-Sequences

All studied flysch series show three characteristic sections :

(1) A relatively turbidity-free pelitic base (for example the " Scaglia rossa " and " Scisti varicolori " at the base of the Macigno and Cervarola-Sandstones and the " Scaglia cinerea " at the base of the Formazione marnoso-arenacea.)

(2) On top of this are develloped the actual turbidity sediments itselves and

(3) finally again a relatively turbidity-free pelitic sedimentation, the so-called top-marls, occur. These sections are called proto-, ortho- and kata-flysch-stage respectively.

Our purpose was to study whether the ortho-flysch stage itself also displays typical development tendencies in either vertical or lateral directions. As working hypothesis it was assumed that the degree of turbiditic sedimentation is either directly or indirectly dependent upon the tectonic events in the areas of origin of the clastic material. We should then be able to draw conclusions as to the extend of tectonic movement in bordering areas from the sedimentological changes of individual flysch sequences. The turbiditic sequences, at first glance uniform, are marked by the regular change from turbiditic sedimented graywacke strata and pelitic interstrata of different origin. Using measurements of stratimetry, grain size distribution, organization of the internal bank textures (according to BOUMA), facies analyses of the interstrata, etc. we have tried to investigate if :

(1) There are significant shifts of the strata-interstrata-ratio,

(2) There is a non-random distribution of the maximum thickness of the graywacke strata within the individual series,

(3) There are certain general features which are typical of a certain section of the trough development in either a vertical or a lateral direction (basin edges, center of trough),

(4) There are superimposed major cycles which are either randomly or significantly distributed.

Methods

First, twelve profile sections were measured bank for bank to get the above mentioned characteristics. This data have been coded, punched, and evaluated with the help of electronic data processing methods. All measured bank thicknesses were drawn by a plotter with the strata on the abscissa towards the right and the interstrata towards the left (Fig. 2). These rhythmograms also contain information about grain size and facies organization.

For a further characterization of the profiles we choose the representation of bank series in a stepwise constant function.

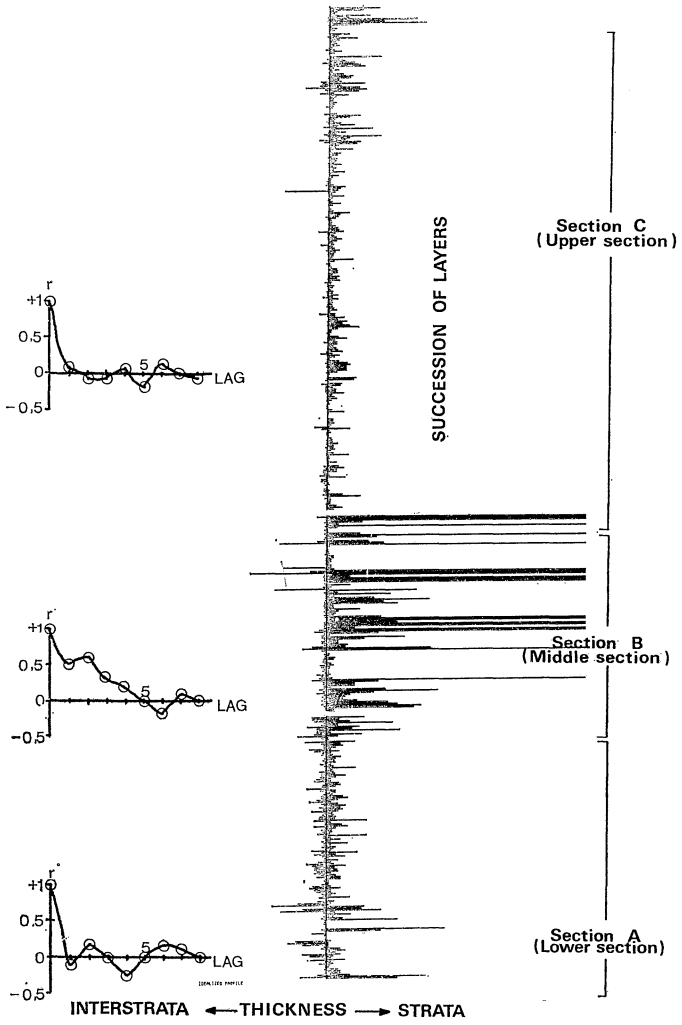

Fig. 2

The thickness of the strata and the interstrata were plotted alternately on the abscissa and the ordinate respectively.

Finally the auto-correlation was calculated for both the strata and the interstrata separately and for both together in order to determine whether there is a relationship between the thickness of successive banks.

Using these analyses it was possible to describe a pattern which fits all series under consideration. This pattern of a completely developed and undisturbed graywacke series displayed three sections superimposed upon each other (Fig. 2).

Section A represents the actual onset of the ortho-flysch stage. The onset of the almost exclusively turbiditic sandstones can be introduced either by thin sandstone beds which slowly get thicker, or by a sudden onset of several thick sandstone beds. The average sandstone bed thickness of this section and the average grain size of the sandstones are smaller than those of section B. The thickness of successive strata resp. interstrata is randomly distributed.

Section B is characterized by the occurence of the thickest turbidites of the entire series. In addition the sandstones and sometimes interstrata, too, are grouped clearly in clusters (megarhythms), i.e. they are not randomly distributed. The correlation of the thickness of successive strata is in general high. The thickness of the interstrata is often very reduced (amalgamated sandstone banks). The increase of the sandstone thickness is usually accompanied by an increase in grain size (up to conglomerates, so-called fluxoturbidites).

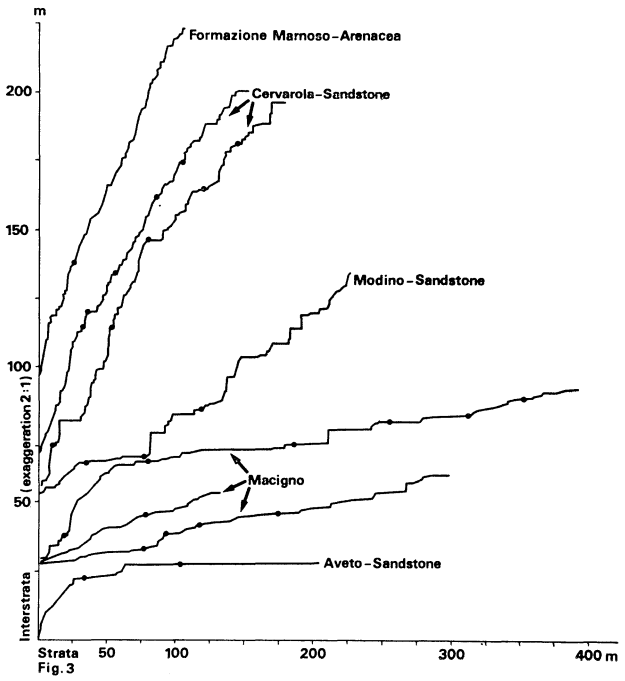

Fig. 3

Section C is similar to section A. There is a marked decrease in the average thickness of the banks and of the average grain size. The area of transition to the almost pure pelitic sedimentation in the upper parts of this section shows sometimes again a distinct increase of the thickness of the sandstone beds.

This pattern is, in principal at least, substantiated in the Aveto-, Modino-, Macigno- and Cervarola-Sandstones, even though the completeness of all three sections could often be observed but not substantiated by data because of the lack of appropriate outcrops. The model could not be verified for the Formazione marnoso-arenacea in all three sections since here we only have data for the basal parts at present. (Personal observation as well as publications by RICCI LUCCHI indicate that this pattern also describes the Formazione marnoso-arenacea.)

A comparison of the stepwise constant functions for the individual sandstones shows another striking characteristic (Fig. 3). The strata-interstrata-ratio, represented by the angle of ascent of the functions slides not only from section A through B to C within the individual series, but also the average angle of ascent of the individual curves is different. The decrease of the strata-interstratà-ratio runs from Aveto- to Macigno- to Cervarola-Sandstones up to the Formazione marnoso-arenacea distinctly the original paleogeographic arrangement of the flysch-basins from SW to NE. Even though the origin of all described functions is not the same (not all the measured series begin directly above the basal pelites), this trend seems to be too marked to be random. An explanation for this phenomena has yet to be found.

General Conclusions

It is assumed that all sections of a flysch trough go through the above described stages of development. The individual stages A, B and C probably contain lateral transitions perpendicular to the strike direction of the troughs. Because of the migration of the trough axes, these stages in each basin ought to become younger from the internal to the external parts in the same way as the entire flysch series do. The absolute thicknesses of the sandstone banks within section B are dependent upon the respective trough and the respective position within the trough. However, the above mentioned relationships between sections A, B and C are relatively constant. Only in those parts which are influenced by events which are not a part of the actual flyschsedimentation (intercalations of olisthostromes, arrival of gravity nappes) this development is disturbed so that a section may be missing. Both in the lateral migration in space and time of the sections from intern to extern, and in the vertical change itself, a migration of the " orogenetic wave " is substantiated.

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