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THE MEDITERRANEAN CYCLONES – THE ROLE IN ENSURING WATER RESOURCES AND THEIR POTENTIAL OF CLIMATIC RISK, IN THE EAST OF ROMANIA

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Key words: Mediterranean cyclones, water resources, climatic risk.

Abstract. The Mediterranean cyclones – the role in ensuring water resources and their potential of climatic risk, in the East of Romania. The mean altitude of Romania's landforms is 420m and the mean annual amount of precipitation is 640mm. The direction of the general atmospheric circulation is everywhere from west to east and that is why in the territories situated to the east of the Eastern Carpathians, in the area of Moldavia, the mean annual amount of precipitation is 560mm. In Romania, the percentage of the precipitation generated by the Atlantic and Mediterranean cyclones is 80%, and the rest of 20% are produced in local circuits (Ujvári, 1972). Due to the obstacle created by the Eastern Carpathians, in Moldavia the pluvio-genetic potential of the west and north-west circulation is very much diminished. The Mediterranean cyclones ensure an important percentage of the total amount of rainfall. For one month a year the studied area is under the influence of these cyclones. Although the distance to the Adriatic and Aegean Seas is only of 700 km, the mountain landforms of the Balkan area diminish the pluviometric capacity of these cyclones. This paper approaches mainly the effects produced by the Mediterranean cyclones that follow the 3a, 4a and especially 3b path (Weather in the Mediterranean, 1962), Vc (Van Bebber), VII (Kriceack, Zverev), and also according to the Romanian researchers (Doneaud, 1957, 1958; Şorodoc 1962; Pribisch, Bordeianu 1966; Grimani, Besleagă, 1976, and others). The Mediterranean cyclones that follow a retrogressive rout high above the Black Sea and to the north of it, have also been studied. The most important events of climatic risk produced by the Mediterranean cyclones in Romania, have been analysed (1970, 1991, 1993)

Introduction

It is few times when Romania's atmospheric circulation - cyclonic or anticyclonic - is very clear. Due to its geographical position, Romania is situated at the crossroad of the main directions of atmospheric circulation, away form the main atmospheric pressure centers. But at the same time, all uncertainties and

contrasts specific to the "wind crossroads" area are part of air circulation in Romania. (Ecaterina Bordei-Ion, 1983). The pluviometric characteristics in the temperate zones are generated by the cyclonic activity, both the amount as well as the regime. The aleatory character of the atmospheric precipitation is also generated by the cyclonic activity (Bogdan, Niculescu, 1999).

While the changes of the active surface (that could generate climatic changes) are extremely rare, and it takes a long time for them to occur, and the solar radiation is a constant climatogenetic factor, the general atmospheric circulation is the fluctuating climatogenetic factor that causes all the non-periodical variations of the climate. The intensity and frequency of the advection processes are reflected in the multiannual regime of the weather, and they become characteristics of the climate in certain areas. Due to these processes, the variation range of the climatic elements, phenomena and processes is considerably increased, and the general atmospheric circulation gives a dynamic regime to the climate (*Clima R.P.R., vol.I*, 1962).

The climate of Romania is a temperate transitional one. The mean altitude of Romania's landforms is 420m and the mean annual amount of precipitation is 640mm. The direction of the general atmospheric circulation is everywhere from west to east and that is why in the territories situated to the east of the Eastern Carpathians, in the area of Moldavia, the mean annual amount of precipitation is 560mm. In Romania, the percentage of the precipitation generated by the Atlantic and Mediterranean cyclones is 80%, and the rest of 20% are produced in local circuits (Ujvari, 1972). Due to the obstacle created by the Eastern Carpathians, in Moldavia the pluvio-genetic potential of the west and north-west circulation is very much diminished. The Mediterranean cyclones ensure an important percentage of the total amount of rainfall. For one month a year the studied area is under the influence of these cyclones. Although the distance to the Adriatic and Aegean Seas is only of 700km, the mountain landforms of the Balkan area diminish the pluviometric capacity of these cyclones. As a complete water circuit, from evaporation to condensation takes around 42 days, the precipitation of local origin, thermo-convective, have a less important role in Romania. They are estimated to represent around 5% of the total amount (Hârjoabă, Crețu, 1984) The remainder of 15% represent precipitation generated by the water vapour that come from continental areas of Europe.

The Eastern part of Romania is situated to the east of Eastern Carpathians, and it is wide open to the eastern part of Europe and to the Black Sea, and this generates significant local changes in the atmospherical dynamics.

This paper approaches mainly the effects produced by the Mediterranean cyclones that follow the 3a, 4a and especially 3b path (Weather in the Mediterranean, 1962), Vc (Van Bebber), VII (Kriceack, Zverev), and also

according to the Romanian researchers (Doneaud, 1957, 1958; Şorodoc 1962; Pribisch, Bordeianu 1966; Grimani, Besleagă, 1976, and others). The Mediterranean cyclones that follow a retrogressive rout high above the Black Sea and to the north of it, have also been studied. The most important events of climatic risk produced by the Mediterranean cyclones in Romania, have been analysed (1970, 1991, 1993)

Due to its heterogenic structure, the earth's surface receives and transforms selectively the solar energy into thermal energy. This complex process generates important baric (pressure) differences between the air masses above large territories, with different characteristics. The differences are generated mainly by the different latitude, as well as by the continental or oceanic nature of the active surface. In its tendency to re-establish the baric equilibrium, the air masses with characteristics similar to the areas above which they were formed, move, changing the main characteristics sometimes, due to the contact with the surface of the territories they cross over and with the local air masses (Bâzâc, 1983).

1. The pressure field

In the month of January, the territory of Romania is situated in the ridge of the euro-siberian anticyclone, and in the month of July, it is situated in a slightly low pressure area, together with the central basin of the Mediterranean Sea, between the Icelandic cyclone (to the north-west), the Arabian cyclone (to the south-east) and the ridge of the Azoric anticyclone (to the west-south-west).

2. The Mediterranean cyclone

The Mediterranean cyclone is a *semi-permanent cyclone* that is formed in the western or central basin of the Mediterranean Sea, on the front generated by the penetration of the polar air over the west and center of Europe, at the contact with the tropical warm air (Geografia României, vol.I, 1983). Most frequently, the Mediterranean cyclone is formed as a result of the penetration of the polar air from Northern Europe, through the east of an altitude ridge, situated in the east of the Atlantic or in the west of Europe. It is also formed by the cyclones that come from northern Atlantic, that regenerate in the Mediterranean area. The regenerations of the north-african cyclones in this area, do not occur so often (Topor, Stoica, 1967). The Mediterranean cyclone is present in the formation area in 41% of the days of the year, as an average. Usually, it is formed in September, reaches a first maximum in October, diminishes and migrates southwards in December-January, due to the intensification of the Azoric and Siberian anticyclones. It intensifies and extends in the month of February, when it migrates north-westwards; in March its intensity and extension diminish and it migrates to the north of the Adriatic Sea. The maximum monthly frequency is recorded in April (47%), and the minimum

frequency in July (31%).. It is not an intense cyclone, its mean annual intensity has the value of 1012 mb, very seldom it can reach 990 mb, therefore, during the warm semester, this cyclone cannot be distinguished on the mean monthly baric maps (Topor, Stoica, 1965).

3. Types of atmospheric circulation

Rodica Stoian and Gh. Neamu (1983) establish four main types of atmospheric circulation for the territory of Romania: western circulation (with a frequency of 45%), polar circulation (30%), tropical circulation (15%) and blockage circulation (10%).

4. The mobile baric formations

The mobile baric formations, anticyclones and especially cyclones, periodically cross the territory of Romania, generating specific weather conditions. An analysis of the movement of the cyclonic formations is essential in the study of the atmospheric precipitation. From the Atlantic polar front, or from other places, isolated cyclones, or, more often, families of cyclones, cross the European continent as well as Romania. From the north Atlantic, 60-70 families of Atlantic cyclones move towards Europe, as an average, every year. They have mean speeds of 20-30km/h and maximum speeds of 80-100km/h. Each cyclonic individual has an average duration of one to two days, but in certain cases it can activate for a whole week (Pop, 1988). Under such circumstances, even if the territory situated to the west of the Moldavian Subcarpathians, up to the Atlantic Ocean, had only plain landforms, and the trajectories of the Atlantic cyclones were directed to this area, the majority of these cyclones would occlude on the way, without affecting the territory of Romania. A part of the Atlantic cyclones move to the Mediterranean Sea. In winter, the route V (van Bebber) starts in Channel, between the Alps and the Pyrenees Mountains, to the north or to the south of the Central French Massif, regenerating in the Mediterranean basin, mainly in the area of the Gulfs of Genoa and Lyon. In summer, the Atlantic cyclones penetrate in the Mediterranean Sea especially through the Gibraltar. From the central Mediterranean Sea and from the Adriatic Sea, these cyclones (or the cyclones generated in this Mediterranean space), follow trajectories that cross Romania or the neighbouring areas, under the name of *Mediterranean cyclones.*

According to the trajectories established by W. van Bebber for the Mediterranean cyclones (fig. 1. and 2.), trajectory Vb is important for Romania, as a summer trajectory over the Panonic Plain, towards Poland and Gulf of Finland,

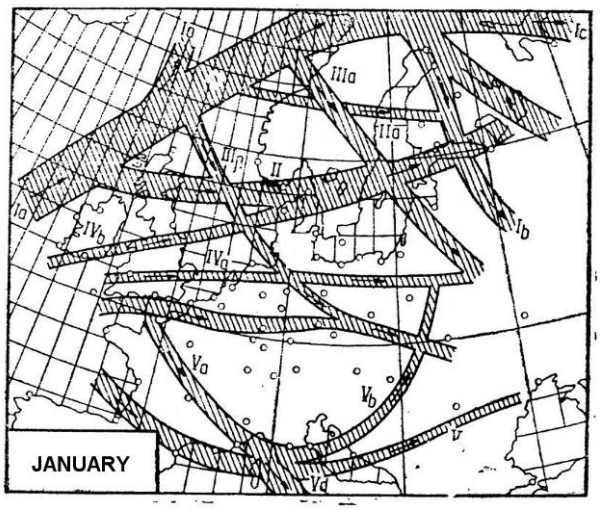

Fig. 1- The trajectories of the cyclones in Europe in January (van Bebber)

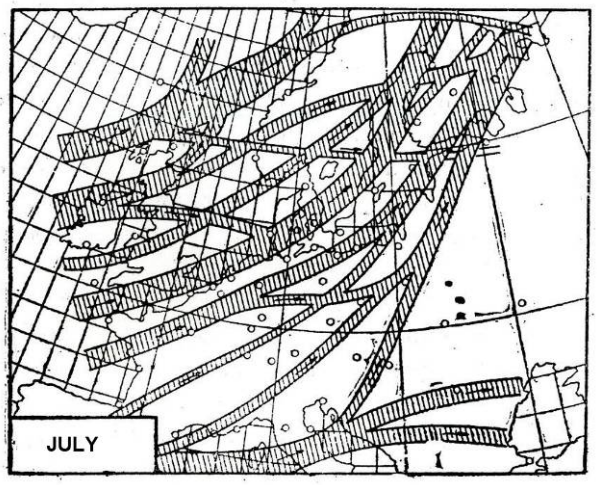

Fig. 2 - The trajectories of the cyclones in Europe in July (van Bebber)

and especially Vc, that crosses from west to east, the south of Romania, in spring and very rarely in summer (Pop, 1988).

According to the trajectories of the mobile cyclones in Europe established by O. G. Kriceak and A. S. Zverev the highest amounts of precipitation with

genesis in the Mediterranean space, for the whole territory of Romania, are produced on the cyclonal trajectory VII (from the Tyrrhenian Sea to Ukraine). For the trajectory VI, situated to the west, the generated amounts of precipitation are lower. On both trajectories, the cyclones circulate especially in autumn and winter. The mountain landforms of the Balkan Peninsula stop the penetration of the trajectory XI to Romania (fig. 3.).

4.1. The Mediterranean cyclones

The Mediterranean cyclones present a special importance in inducing the weather conditions, the amount and regime of atmospheric precipitation in the Moldavian Subcarpathians.

Among the cyclonal paths with influence upon Romania's weather and climate, the Mediterranean and retrogressive cyclones are to be mentioned, because of the high amount and precipitation and special phenomena they generate. Both categories are characteristic to the south-east of Europe and they have a significant role in inducing the main characteristics to the amounts and regime of precipitation in the Moldavian Subcarpathians. Therefore, a detailed research on this problem is needed. In 1931, E. Otetelişanu noticed the role of the mobile Mediterranean cyclones (especially those following the Ist path - Adriatic Sea - Baltic Sea, over the Panonic Plain) in the genesis of intense and long precipitation, and of the floods in Romania.

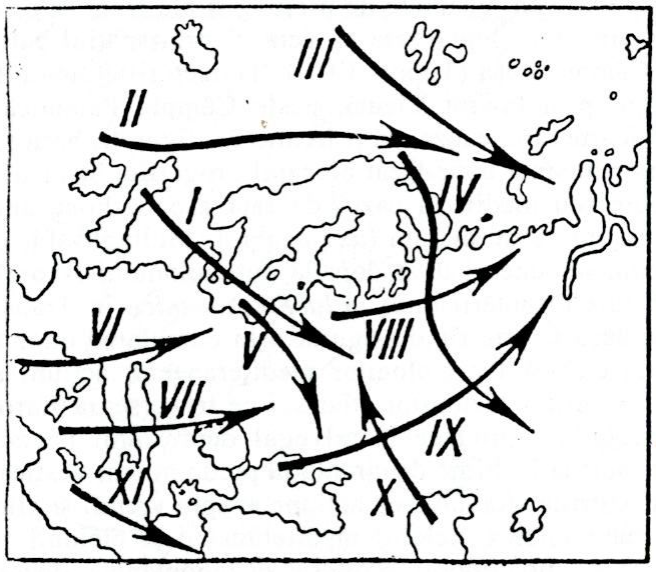

Fig. 3 - Cyclonic trajectories in Europe (after O. Kriceak and A.S. Zverev)

In *Weather in the Mediterranean* (1962) three paths of the Mediterranean cyclones that interest the territory of Romania are mentioned: 3a, from the North Adriatic Sea to the Moravia Pass; 3b, from the Central Adriatic Sea to the south of Moldavia, and 4a, from the Aegean Sea to the Black Sea. The eastern part of Romania is mainly under the influence of the 3b cyclonal path (fig. 4).

Fig. 4 - Cyclonic paths over the Mediterranean Sea

Most of the Mediterranean cyclones have their origin in the northern area of the Mediterranean Sea: in the Gulf of Genoa (50%), Gulf of Lyon, northern Italy and northern Adriatic Sea. The penetration of the cold air from north west, north and north east generates significant temperature contrasts that facilitate the genesis of these cyclones. Most of them move to north-east and east. The movement direction is determined by the baric topography in altitude, and has nothing to do with the place they are formed or with landforms. When cyclones are developed in the lower Danube Basin and in the Black Sea Basin (as a result of cold air invasions that cause significant thermo-baric contrasts) they still belong to the Mediterranean Space. When the Mediterranean cyclones cross mountain chains, orographic occlusion occurs, and then, they are reactivated (Şorodoc, 1962). For the territory of Romania the following paths of the Mediterranean cyclones are important (Şorodoc, 1962):

- type 1, with a trajectory from the Gulf of Genoa to the northern Adriatic Sea, Panonic Plain, Poland. Only 25% of them (with an average of 3 per year)

generate precipitation over the territory of Romania. These precipitation are moderate, 10-30mm. In the warm season, 60% of the cases are recorded;

- type 2 a, with the trajectory from the north-west of the Mediterranean Sea, rarely from the Tyrrhenian Sea, over the Balkan Peninsula, Bărăgan, Dobrudja, occluding in the center of Ukraine. These cyclones occur with an average frequency of 2 cyclones per year, 60% of the cases in the cold season. They produce precipitation of 20-25mm in the Eastern Romania;

- type 2b, with the trajectory from the Ionian Sea, over the Balkan Peninsula, Marmara Sea, to the east of the Black Sea. They produce weak precipitation in the south-east of Romania (around 5 mm) and they have the average frequency of 5 cyclones per year;

- type 4 (with three paths: 4a, 4b, 4c) is the most frequent type in the Mediterranean area (41% of the Mediterranean cyclones). Annually, 10-11 cyclones of this type influence the weather conditions in Romania. Only those following the 4a path produce precipitation all the time, but they have a reduced frequency (one cyclone every two years) (Şorodoc, 1962), (fig. 5).

The territory of Romania is annually under the influence of around 24-25 Mediterranean cyclones (as an average), but only 23% of them cross the territory of Romania with their core, 70% of them in the cold semester, 40% in winter, and in the month of August only one cyclone every two years. In those cases when the cyclonic cores are far from the territory of Romania, only significant cloud cover occurs.

In the second half of autumn and in the month of March, the precipitation regime is mainly generated by the position of the Siberian Anticyclone. If its core is centered in the northern half of Asia, the main route of the series of cyclones from the Mediterranean Sea passes over Romania (Platagea et al, 1966).

The evolution of the Mediterranean cyclones is connected to the position of the axis of the jet streams. The Mediterranean cyclones are formed when the curves of the jet streams go down to the south, in the Mediterranean Basin. *The presence of the jet streams over the formation area and the maintaining of the jet stream in the following days too, is compulsory to the formation of the cyclones.* (Pribisch, Bordeianu, 1966). The formed cyclones are moving to the north-east occur further than 600 km away from the axes of the jet streams routes (fig. 6.).

For Romania, the cyclones formed in the A area in the Western Mediterranean (those following the II trajectory, over the Balkan Peninsula, Carpathians, Ukraine, Russian Plain, reaching the northern Ural mountains sometimes), and those formed in the B area, in the central – eastern Mediterranean (with a trajectory over the Aegean Sea, Black Sea, reaching the southern Ukraine) are important (Pribisch, Bordeianu, 1966), (fig. 7).

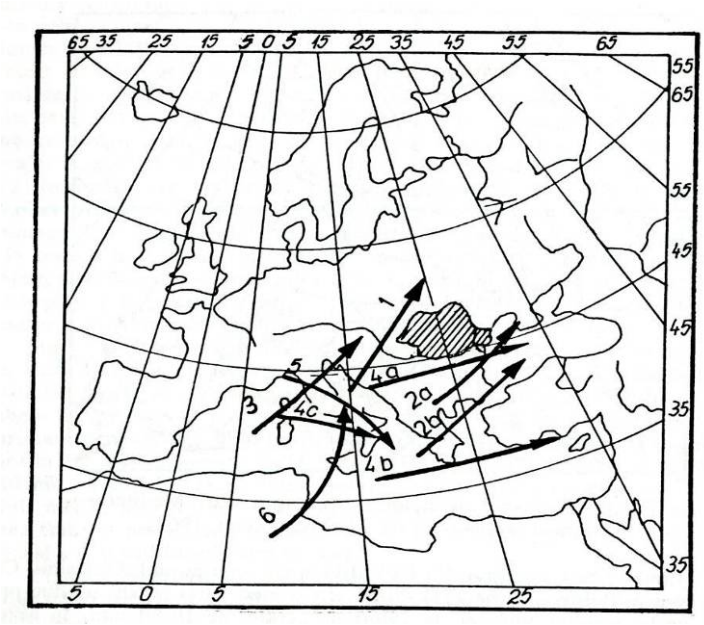

Fig. 5 - Mediterraneans cyclonics paths (after Şorodoc, 1962)

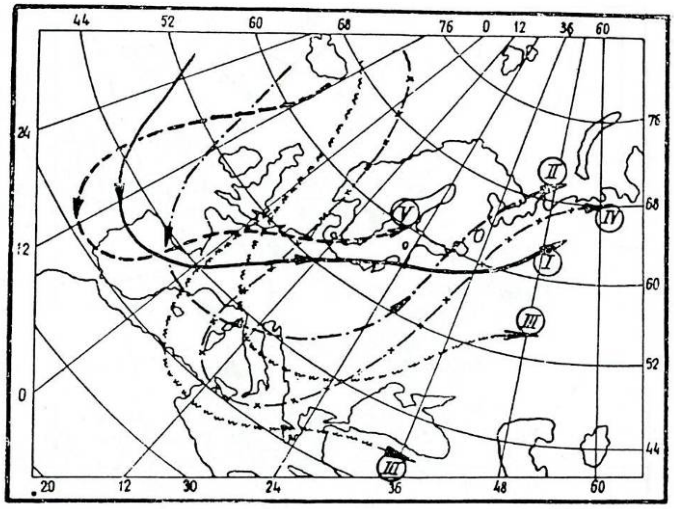

Fig. 6 - The medium positions of the jet stream axis according with each synoptic processes type (Pribisch, Bordeianu, 1966)

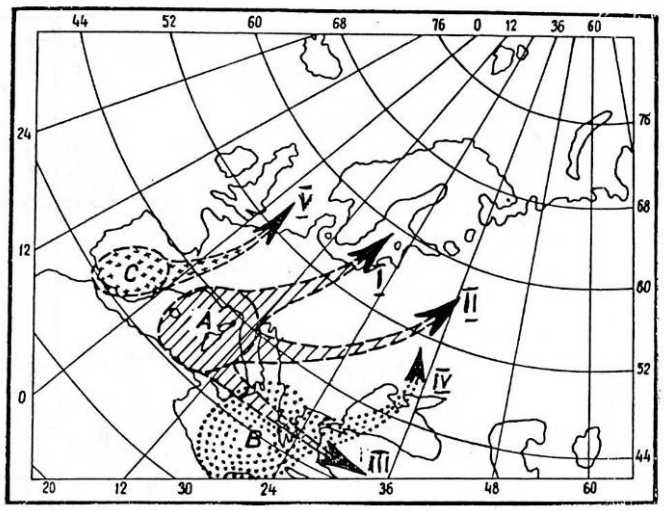

Fig. 7 - Genesis areas and the medium paths of the mediterranean cyclones

The precipitation generated in the east of Romania by the cyclones with deviation from the I trajectory, that cross (with their core) the Eastern Carpathians, are reduced. In this area the regeneration of the core and of the system of fronts occur, after the partial occlusion caused during the crossing or after the fragmentation of the cyclonic core (Ujvári, 1972).

By analysing the cyclones formed in the Mediterranean area in the period 1955-1974, Doina Grimani and N. Beşleagă (1976) lead to the conclusion that in 33% of the cases, their movement speed was under 20km/h, in 45% of the cases it was between 20-50km/h, and in 22% of the cases, it was over 50km/h.Three general routes have been established, starting from the center of Western Mediterranean Sea: I, over the Ionian Sea, Greece, Aegean Sea, Marmara Sea, Black Sea: II, over Italy, to the Central Adriatic Sea; III, over Italy, North Adriatic Sea, Panonic Plain, to the south of Poland (fig. 8).

The Mediterranean cyclones that follow the route I are specific to the warm semester (67% of the total), in most of the cases they produce precipitation over the territory of Romania (in 43% of the cases the precipitation exceed the amount of 25 mm).

The Mediterranean cyclones that follow the route II do not have an important influence on the weather in Romania.

The Mediterranean cyclones that follow the route III represent only 7% of the cyclones that form in the Mediterranean Basin; 67% of them are formed in the cold semester, mostly in the first part of spring. Most of them produce weak

precipitation in Romania (under 5 mm), and only 25% of them produce precipitation exceeding this value.

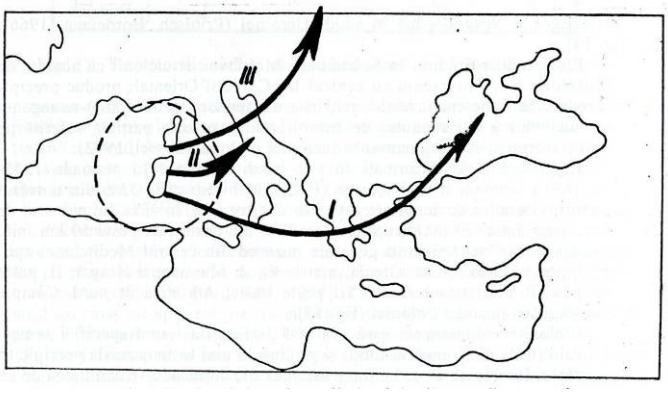

Fig. 8 - Paths types of the Mediterranean cyclones (Grimani, Beşleagă, 1976)

The Mediterranean cyclones formed outside the mentioned area, following routes that are different than types I-III are very rare and they produce precipitation in Romania only in 10% of the cases (Grimani, Beşleagă, 1976).

The most detailed analyses on the Mediterranean cyclones were done by Ecaterina Ion-Bordei (1970, 1972, 1976, 1983, 1986). The research is synthesized in the work entitled *The role of the Alpine and Carpathian mountain chain in the evolution of the Mediterranean cyclones* (1983), based on a period of analysis of 20 years (1960-1979). Most frequently, the Mediterranean cyclones are formed under the conditions of an anticyclone in the western Europe, moving towards Central Europe, and of a low pressure area in the Central and Eastern Mediterranean Sea, in the Balkan Peninsula and in the eat of Europe (Ion-Bordei, Limbaseanu, 1976).

The cyclones that follow the classic route I (Bordei-Ion Ecaterina et al, 1976, 1979, 1983) represent 32% of the cyclones that are formed in the Mediterranean area, and 54% of them are formed in the warm semester. Usually they become stationary for 6-18 hours in the Panonic Plain, where they regenerate very often. They seldom produce weak precipitation in western Romania. In the Moldavian Subcarpathians it is just the advections of tropical air that can be noticed, with clear sky and excessively high thermal values. When the cyclonal area is larger, heavy rains are recorded in the east of Romania as well. Of the total cyclones that followed this route, in a period of 5 years, only 10 cyclones influenced the territory of Moldavia, usually for 2-3 days, generating average precipitation of 8-15mm for each case (Ecaterina Ion-Bordei, 1983).

For the territory of Romania the deviations from the route I are significant (Ion-Bordei, Limbasanu, 1976, Ecaterina Ion-Bordei, 1983), (fig. 9).

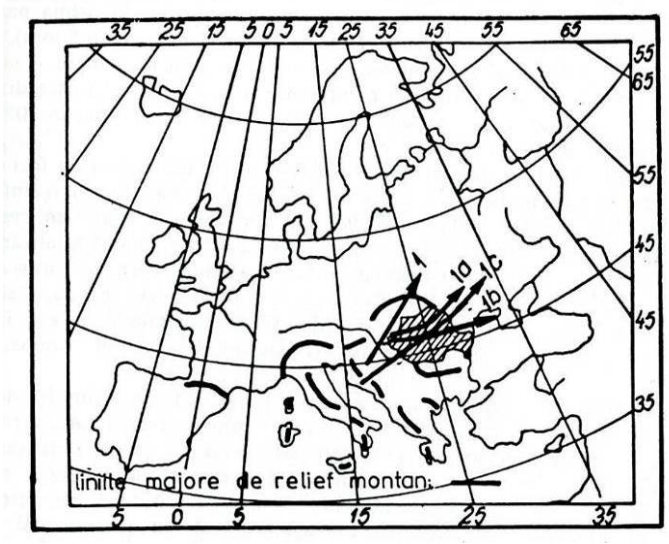

Fig. 9 - The deviations from the route I of the mediterranean cyclones

Out of 166 cyclones present in the Panonian Plain on the classic route I, in the period 1960-1979, only 61 followed the path, while 105 were deviated eastwards (Ecaterina Ion-Bordei, 1983). After being stationary for 12-18 hours in the Panonic Plain, where regenerations also occur, the core of the cyclone crosses the Western Carpathians, reaching the Transylvanian Depression in 6 hours, then Eastern Carpathians, and after 6 more hours it reaches Moldavia. These are record intervals for crossing two mountain barriers. The anticyclonic barrier situated in the north-west, north and north-east controls the deviation from the route, and one single path is possible: crossing the low mountain groups of the Carpathians. All the landforms of the Balkan Peninsula and the whole Carpathian mountain chain, from Viena to the Timoc valley are not capable to induce changes in the directions of the classical route I, or of the deviations from this route. Only decreases of intensity and occlusions while crossing the mountains, and regenerations after the crossing of the barriers occur. In the middle area of Moldavia, along the Siret River, the most intense precipitation occur. The precipitation decrease eastwards in the phase before the occlusion, and westwards, in the Moldavian Subcarpathians, where the effects of the foehnisation are visible (Ion-Bordei, Limbasanu, 1976). In the warm semester, the warm front and then the cold front of these cyclones, cross the Oriental Carpathians and Moldavian Subcarpathians, from south-west to north – east. While in the Retezat Mountains, the two front passages produce around 90 - 100mm precipitations, in Moldavia the amounts decrease to 40-60 mm (Ion-Bordei, Limbăseanu, 1976). In the cold semester, the movement of the cyclones

along the paths deviated from the classic trajectory I is very rapid, and the precipitation are recorded especially in the west of the country, in the peripheral parts of the warm fronts. Within the cold fronts that cross Romania in these cases from south-west to north-east, precipitation are more consistent and generalized sometimes. When the core of these cyclones reaches Transylvania, most of the precipitation move to Moldavia, where they transform into sleet and snow.

The deviations from the classical route I have three paths usually: 1 a, from the Panonic Plain, over the Western Carpathians or Somes river basin, usually crossing Eastern Carpathians over the Bârgău-Dorna-Modova Depressionary Corridor, to Podolia; 1 b, from the Panonic Plain, through south Transylvania, over the south of the central group of Eastern Carpathians, through south Moldavia, to Crimea; 1 c, from the Adriatic Sea, over Bosnia – Herzegovina, Serbia, Banat, over the south group of Eastern Carpathians or the south of the central group of Eastern Carpathians, central Moldavia, occluding in the center of Ukraine (Ecaterina Ion-Bordei, 1976, 1983).

The Mediterranean cyclones have the most visible effects in winter, when they cause an increase in air temperature, and they produce mainly rainfall, they stop the formation of a stable long duration snow layer. Sometimes, in combination with the Siberian anticyclone they contribute to the generation of severe weather conditions and the formation of "crivăț". They produce an important part of the total annual amount of precipitation, sometimes they produce floods, they significantly disturb the classical annual regime of atmospheric precipitation and they have the main role in the producing of the sub-Mediterranean influences in Romania (Ecaterina Ion-Bordei, 1983). At the same time, they are the main generators of dust storms and of coloured precipitation (Runcanu, Stancescu, 1975; Ecaterina Ion-Bordei, 1983). The route of the Mediterranean cyclones does not consider the formation place but only the baric topography, and their trajectories are not exclusive, as they are only preferential paths. The presence of the Mediterranean cyclones has a significant contribution to the genesis of the climate of south-eastern Europe. The Mediterranean and sub-Mediterranean influences are not generated by the static presence of the Mediterranean Sea in this area (especially considering the large areas with mountain landforms that separate the Mediterranean basin from the Danubian - Pontic area), but by the energetic and humidity transfer, with all the phenomena that accompany it. The general atmospheric circulation transports the elements generated in this way to the Carpathian territories (Ecaterina Ion-Bordei, 1983). The frequency, duration, amount of precipitation, the temperature increase generated by the Mediterranean cyclones, with normal trajectories, with deviated trajectories and of those that become retrogressive, as well as the precipitation maximum recorded in the second

part of autumn, in the south of Walachia, represent ways of approaching the *Mediterranean influences* in Romania.

4.2. The retrogressive cyclones

The retrogressive cyclones as depressionary formations that deviate from the classical wet-east route, going towards west and compulsorily passing the north, are specific to the whole continental European are, but mainly to the south-eastern part of Europe (Exner, Palmen, Bjerknes, Mildner, Weickman, cited by Ecaterina Ion-Bordei, 1983). In the interwar period, significant contributions to the understanding of the mechanisms of movement and of the structures of these cyclones have been brought. The following idea was stated: if the deviation from the trajectory can be included in the limits of a certain normality, then it is abnormal the completely reversed situation, as compared to the normal cyclones, of the warm and cold sectors. Such opinions are supported by more recent research (Ecaterina Ion-Bordei, 1983).

The retrogressive cyclones have a quite high frequency in the studied area and they produce very intense meteorological phenomena, abundant rains, thunderstorms, snowstorms. They affect the area of the Moldavian Subcarpathians in all the seasons, but mainly in the cold period of the year, when their intensity is also higher. The evolution of the retrogressive cyclones have a duration of two to nine days (Struțu, Militaru, 1974). The most intense are those whose retrogressive route cross the Black Sea, where they regenerate. The retrogressive direction, towards north and north-west, is produced by the existence, in the east and north-east of the Black Sea, of a high pressure area.

For the period 1960-1970, Struțu et al (1972, 1974) recorded 80 situations when the retrogressive cyclones affected the territory of Romania. For an annual average of 7 retrogressive cyclones, with an average duration of four-five days, the impact of the retrogressive I cyclones is present one month a year (the remarkable effects consist in one quarter of the annual average number of days with precipitation or covered days, and a third of the average amount of precipitation fallen in the Moldavian Subcarpathians). These results are added to some similar effects produced by the normal Mediterranean cyclones, whose trajectories influence the territory of Romania. Considering that 37% of the retrogressive cyclones come from normal Mediterranean cyclones, one can estimate that, on the whole, the Mediterranean and retrogressive cyclones influence the territory of Romania by means of precipitation, or just cloud cover or thermal changes, for about two months, generating almost half of the annual amount of precipitation. The passages of the retrogressive cyclones over the territory of Romania occur in all the months of the year, with a maximum frequency in the cold season. The convergence of air currents in front of Eastern Carpathians and the orographic

convection processes generate important precipitation in the Moldavian Subcarpathians, and they constitute active factors in the regeneration of the cyclonic cores in the phases that precede the occlusion. The orographic reactivation of the fronts of these cyclones, in the Moldavian Subcarpathians, produces significant amounts of precipitation. Most of these cyclones do not succeed in crossing the Carpathians (Doneaud, 1958; Struțu et al, 1972, 1974; Ecaterina Ion-Bordei, 1983; Ailoaiei, 1989 etc.). The structure of the baric field characterized, in all the cases, by the existence of an anticyclonic barrage in the center and north of Europe and a depressionary area in the eastern basin of the Mediterranean Sea and in the north-western area of the Black Sea. The movement of the cyclone south to the high altitude frontal zone, suddenly changes the zonal orientation of the circulation, from west to south west, from the Aegean Seam, over the Black Sea, also facilitating the penetration of the polar air masses from the Baltic Sea towards the Panonic Plain. The thermal difference between the two air masses, of 8-10°C, together with the local geopotential differences cause the retrogressive cyclones evolution phases. For 500mb, air temperature reaches -25:-35°C, the cold air becomes descendent at the south of the cyclone, and warm air becomes uprising at the north of the cyclone. The warm front becomes stationary to the north of the cyclonic core, an the cold front to the south, in the periods of cyclone rotation. The existence of a asymmetry of pressure and temperature between the soil surface center and the high altitude cyclonic core, causes a sudden rotation of the trajectory of the retrogressive cyclone, from north-west, to south-east.

Most of the retrogressive cyclones have their origin in the territories between the Caspian Sea and the Carpathians, occluding in Scandinavia or Northern Germany (Doneaud, 1956). Their effects in the area of the east of Romania are reduced. From the three groups of retrogressive cyclones established by Struțu et al, (1972, 1974), two are mediteraneean (fig. 10) and have a different influence in the studied area:

- the retrogressive cyclones with the origin in the Gulf of Genoa and in the north of the Adriatic Sea (II, 37% of the retrogressive cyclones), cross the center of the Balkan Peninsula, they reach the Western basin of the Black Sea, they evolve over Western Ukraine, they attack from north-east the northern or central group of Eastern Carpathians, that they usually do not succeed in crossing, they come back in the central Moldavia, then they cross Ukraine again, the area of Moscow and they occlude over the Baltic Sea. They have two rotation periods, they last for 2-5 days and they produce an average of 80-90mm of precipitation, especially in Moldavia, Bărăgan and Dobrudja;

- the retrogressive cyclones formed in Asia Minor (III, 13% of the number of the retrogressive cyclones)have three rotation periods. After crossing the Black Sea, they reach the south group of Eastern Carpathians and they go back to the

Black Sea basin. They produce an average of 80-100mm of precipitation , they last for 5-9 days and they have effects on the south of Moldavia, Walachia and Dobrudja. In the Moldavian Subcarpathians they affect only the southern half.

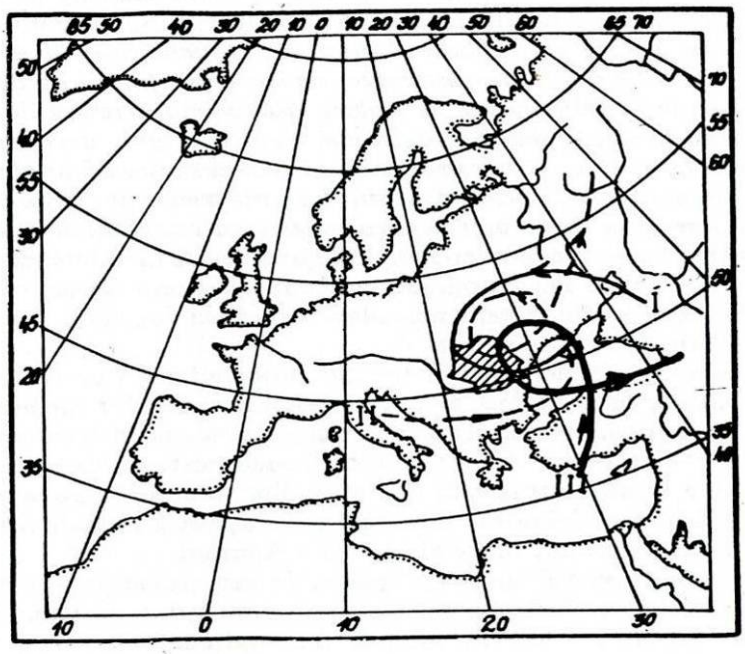

Fig. 10 - The evolution of three groups of retrogressives cyclones (Struțu et al, 1972)

In most of the cases of retrogressive cyclones, the wind blows strongly (60-70km/h) from north-north-east, and, depending on the rotation periods, the weather conditions are different on one side and the other side of Eastern Carpathians, and even between the north and south of the Moldavian Subcarpathians (Struțu et al, 1972, 1974).

Sometimes, the trajectories of the 2 a and 2 b Mediterranean cyclones (Șorodoc, 1962) deviate, becoming retrogressive, crossing Moldavia from south to north (Ecaterina Ion-Bordei, 1983).

The retrogressive cyclones, as well as the "crivat", constitute a way of periodically expressing the influence of the Black Sea, towards east and north – east, to the territory of Romania.

The influence of the Mediterranean and retrogressive cyclones are reflected directly and indirectly in the climate; although their frequency is not very high, the manifestations are intense, especially in the cold season (Topor, Stoica, 1965). The greatest snowstorm of the century in Romania, in 1954, 1-4 February, was

produced under the action of a Mediterranean cyclone (Bălescu, Beşleagă, 1962). The greatest part of the atmospheric precipitation in the south of Romania is due to the south-western, southern and eastern circulations accompanying the Mediterranean and retrogressive cyclones. In the area of the Moldavian Subcarpathians, the pluviogenetic potential of the western and north-western circulations is drastically diminished by the Eastern Carpathians. Under such circumstances, the Mediterranean cyclones that cross the country, those that become retrogressive in Moldavia as well as those that become retrogressive over the Black Sea, have a substantial contribution to the realization of the annual amounts of precipitation. In Moldavia, the precipitation of Atlantic origin are reduced, as they are diminished on their long way, and also as a result of the foehnal processes in the eastern ridge of the Oriental Carpathians and in Moldavian Subcarpathians. *If it were not for the Mediterranean cyclones, the aridity of eastern Wallachia, as well as the aridity of Moldavia, would have been excessive, as a result of the foehnal processes in the Eastern Carpathians, knowing the predominance of western circulations in this part of the country (Ecaterina Ion-Bordei, 1983). The spectrum of the Mediterranean influences, even not so clear, is more extended, as they are involved especially in the realization of the precipitation amount for the whole country, as well as in the annual temperature regime. These influences have a moderating effect on the continental excessivity in the extra-carpathian areas.* The Mediterranean cyclones with normal, deviated or retrogressive trajectories, as well as the retrogressive cyclones with other formation areas, generate precipitation mainly in the second half of autumn and the beginning of winter.

Considering the activity of the Atlantic cyclones that move along trajectories situated north to the Carpathians, the activity of the Mediterranean cyclones and of the retrogressive cyclones, the amounts of precipitation generated in the Moldavian Sucarpathians, at the contact with Eastern Carpathians, are much higher than the estimations in the literature. For the altitude of 400-800m, precipitation are only 15% lower than those recorded in the hilly area situated west to the Eastern Carpathians, and 20% lower than the western slope of Western Carpathians.

5. The climatic risk potential of the Mediterranean cyclones

The highest amounts of rainfall in Romania have been recorded at the contact of two maritime air masses, one of which is tropical, when the air is maintained unsaturated at the clouds level, their base is situated at the altitude of 1-1,5 km, and the upper ceiling of the clouds do not exceed the altitude of 7.5 km (Topor, 1970).

In Romania, in the hilly or mountain areas, for the floods to produce, when the soil is dry, precipitation amounts exceeding 30mm in 24 hours are required.

The phenomenon is aggravated if, both in the preparation stage of the floods as well as in the moment when they occur, precipitation have an intermittent character, they fall under of forms of showers, and their duration is of 2-3 days for each phase (Stoica, Struțu, 1964). The frequency of the floods starts to increase in October (when the minimum is recorded), until December, then a slight decrease is recorded in January, due to the low temperatures, and then the increase continues until March (when the maximum frequency is recorded), due to the association, in some cases, between the abundant precipitation and the melting of the snow layer. A slight decrease follows in April, then significant increase in May, due to the abundant precipitation and the relatively wet soil. After that, the frequency of floods decreases until October. Due to the melting of the snow while frequent warm air invasions occur during winter, the frequency of floods is higher than in summer (26%, as compared to 21% of the total number of floods), (Stoica, Struțu, 1964). A major cause is represented by the Mediterranean cyclones (Niculescu, 1986).

Among the exceptional amounts of precipitation that have produced catastrophic floods in Romania over the last decades, we can mention those produced in May 1970 (Topor, 1970, Podani, Zăvoianu, 1971 etc), generated by the contact of the fresh tropical maritime air (with a specific humidity of 15-20g/m^3), with the polar maritime air coming from above the North Sea.

The exceptionally abundant precipitation in the period 1-3 June 1975, produced the highest amount of water ever recorded in Romania for a large area, in a such short interval. The affected area included around 40% of the surface of Romania, that is its central-southern part. For the majority of the precipitation recording stations situated in the center of this area, the absolute maximum in 24 hours was recorded in this period. These precipitation were generated by the penetration of a polar humid cold air from Scandinavia, over the Balkan Peninsula, through a trough, that contacted, in Romania, the tropical humid air dislocated to north.

The amounts of rainfall caused by the very unusual meteosynoptic conditions, in July 1991, produced between 200 mm and 400 mm at the east of the Eastern Carpathians. On the 3rdJuly 1991, a cyclone with retrogressive character crossed the west of Moldavia, generating catastrophic effects. In the interval 26-30th July, in 48 hours, in the west of Moldavia, the precipitation amounts varied between 150 mm and 220 mm, causing floods in the Siret river basin (Stăncescu, Goți, 1992).

The synoptic situation of the interval 26-30th July 1991, was generated by the intense activity of a cyclonic perturbation situated in the depressionary trough of a cyclonal area, with the center in the north-eastern extremity of Europe. This area presents temperature and humidity contrasts between its warm sector, dominated

by the tropical air, with temperatures of 18-23° C and its back part, with temperatures of 12-25° C. The cyclone situated above the Black Sea, moved retrogressively at the end of the interval -which is a very rare situation in July - causing an intense reactivation of the rains. The river flows increased: the Tazlău river (with an average flow of 4m/s), increased to over 1500 m/s destroying the Belci dam and producing lots of human and material loss.

The contact between the tropical maritime air of Mediterranean origin and the polar maritime air, generated numerous floods in the west of Moldavia in the month pf July, 2004, as well.

Conclusions

For such events, the data series used by the hydrologists prove to be too short. According to the processed data, the assurance degree in the case of such events was 1/1000 years. Therefore, it is necessary to use the climatic data (that cover periods over 100 years) and also, the re-dimensioning of the hydro-energetic fitting outs in accordance with the new assurance degrees, is required (Podani, Zăvoianu, 1992).

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