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TECTONIC EVOLUTION OF NUGRUS-SIKAIT AREA, SOUTH EASTERN DESERT, EGYPT

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ABSTRACT

The exposed rocks at Nugrus–Sikait area are composed of mafic–ultramafic rocks, ophiolitic mélange, metasediments, granitic rocks (biotite granite, muscovite granites and pink granite) and post granite dykes and veins The area comprises two napps (ophiolitic rocks and arc assemblage) separated by tectonic mélange rocks. The structural elements in the study area are treated under several categories; thrusting, bedding, foliation, folding, boudinage, faulting and fracturing.

Thrusting is the oldest structural phase in the study area, where Nugrus thrust is considered as a major thrust with many minor thrust faults. More than one episode of deformation was identified. The presence of more than one type of foliation planes (S_1& S_2), may indicate more than one deformational events were affecting the study area.

Planar and linear mesoscopic structures exhibited by the metamorphic rocks indicate that they are involved in supper-imposed folding events and at least two fold episodes (F_1 and F_2) can be recognized. The F_1 folds resulted in isoclinal folding of S_0 around N10°W and plunges 60°. The F_2 folds refolded F_1 folds into overturned and recumbent folds about S45°E axes and plunges 16°.

Key words : Tectonic, Nugrus, Sikait, folding, nappe.

INRODUCTION

The Nugrus-Sikait area covers about 200 km^2 (Fig.1). it is selected for structure analysis because it represent the eastern continuation of Migif-Hafafit culmination which in turn is considered as one of the most important key regions in interpreting the tectonic environment and evolution history of the Egyptian basement complex.

Based on metamorphic grade and complexity of deformation, El Ramly et. al. (1993) divided Hafafit-Nugrus area into two major groups separated by a low angle thrust and intruded by the late granitoids (Fig 1). The lower group comprises the Migif-Hafafit gneisses (MHG) and associated rocks and characterized by medium grade metamorphism and complex deformation. The upper group, known as Ghadir group (GHG), tectonically overlies the first group and characterized by relatively low metamorphic grade and simpler deformation (El Sharkawy and El Bayoumi 1979 and El Bayoumi 1984). The two groups are separated by a major thrust, known as the Nugrus thrust, which runs along the upper part of Wadi Sikait in a NW direction. The MHG comprises the footwall of the Nugrus thrust, while the GHG comprises its hanging wall.

The mafic–ultramafic rocks, ophiolitic mélange and metasediments which exposed in Nugrus-Sikait area were studied petrographically in detail by several workers (Hegazy, 1984; Eid, 1986; El Magraby, 1994; Saleh, 1998; Ibrahim et al., 2000). The present study is concerned to geologic setting and tectonic evolution of the Nugrus–Sikait area.

GEOLOGIC SETTING

Based on field observations and structural relations, the exposed rocks, in the study area, are mafic–ultramafic (peridotites, serpentinites, metagabbros) ophiolitic mélange, metasediments, granitic rocks and post-granite dykes and veins (Fig. 2). Sikait–Nugrus metamorphic exposures are represented mainly by two nappes; upper nappe (ophiolitic rocks) and lower nappe (arc assemblage). These rock associations are intruded by granitic rocks.

1- Upper Nappe :The dismember ophiolite represents the oldest rocks exposed in Sikait–Nugrus area. It is mainly represented by meta–peridotites, meta–pyroxenites and metagabbros. These rocks are highly tectonized and form fold thrust sheets.

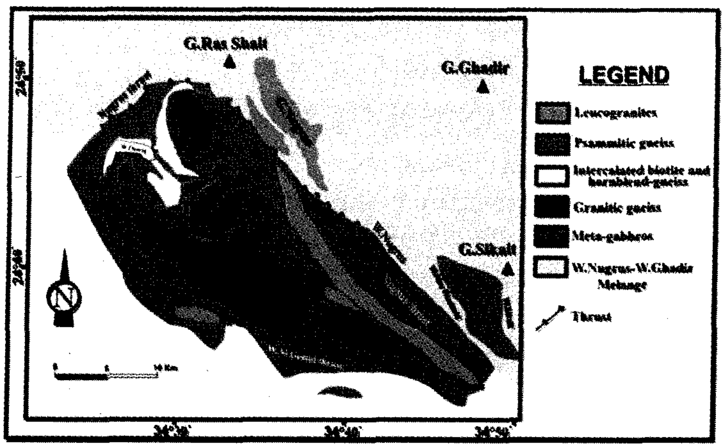

Fig (1): Regional geologic map of Nugrus-Sikait area, Southeastern Desert, Egypt (after El Ramly et al., 1993).

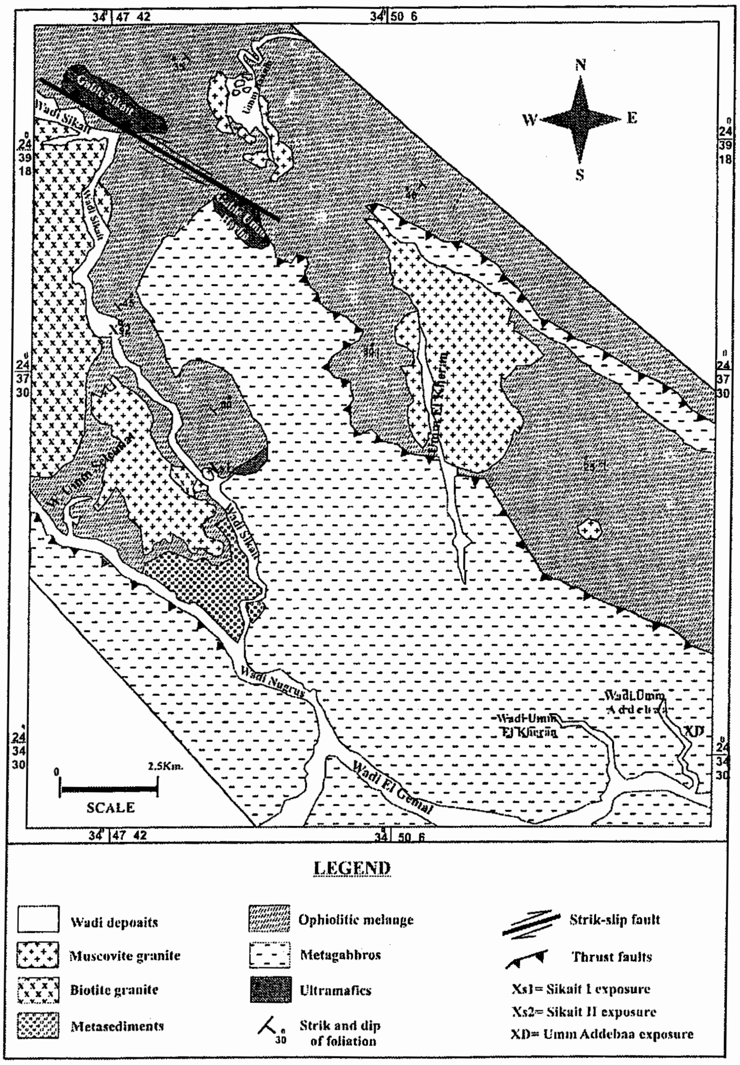

Fig. (2): Geologic map of Nugrus-Sikait area.

The ultramafic rocks are thrusted over the mafic and ophiolitic mélange by WNW-ESE faults and dipping NNEdirection .They are characterized by tholeiitic, high–Ti ophiolite (MORB), equivalent to metamorphic peridotites and ultramafic cumulate of low temperature Alpine type (Saleh, 1997). The presence of chromite pods classifies the presented ophiolitic rocks with the harzbargite ophiolite Types (HOT) indicating their formation in high temperature, high spreading rate and high degree of mantle partial melting environment. The mafic rocks are tholeiitic.

High alumina, high Ti ophiolite and equivalent to oceanic gabbros (MORB) and back-arc basin (Saleh, 1997).

The mafic rocks(metagabbros) are highly tectonized and form fold thrust sheets around W. Sikait, W. Nugrus and W. Abu Rusheid .They are thrusted over both ophiolilitic mélange (Fig. 3)and pelitic rocks (WNW-ESE and dips 33^0/NNE). This thrust is assigned to an age between 682 Ma (the time of emplacement of the older granitoids) and 565-600 Ma, the time of intrusion of the younger granites (Stern and Hedge, 1985). The metagabbros are tholeiitic, high alumina, high–Ti ophiolite and equivalent to oceanic gabbros and back–arc basin (Assaf, et al., 2000).

The ophiolitic mélange is characterized by tectonically mixed fragments and blocks of ultramafic rocks within fine to coarse-grained matrix. It composed mainly of mélange matrix (mainly schists) that encloses abundant fragments of meta-peridotites, meta-pyroxenites and meta-gabbros of variable sizes and dimensions (Assaf et al., 2000). The mafic-ultramafic fragments mostly highly serpentinized and in many places transformed into talc-carbonate rocks which creamy in colors. Those fragments occur in various sizes, reaching big slabs or mountainous size. These matrixes are characterized by layering (Figs. 4 & 5) highly foliated (Fig. 6) and featured by the frequent presence of folds (macro – and meso-dimension, Figs. 7, 8 &9), pencil structure (Fig.10). The matrixes are represented by wide varieties (talc schist, quartzo-feldspathic schist, garnet-mica schist, tourmaline-garnetiferous-biotite schist, graphite schist and sillimanite schist).

2-Lower Nappe

The arc assemblages are mainly composed of volcanogenic sediments, metapelites (,biotite schist, garnetiferous schist), metacalc-pelites(hornblende schist) and arc plutonites (diorites and quartz diorites)outside the mapped area. The metasediments display also relics of primary bedding, foliations, laminations, minor and macro-folding and are highly folded. These rocks are generally intensively deformed and show clear gradual variation from low grade schist facies at the upstream of W. Nugrus (epidote and chlorite facies), thorough the medium grade amphibolite facies (W. Abu Rusheid and downstream of W. Nugrus) to high grade amphibolite facies in tectonic mélange along W. Sikait (staurolite– kyanite–sillimanite facies) (Surour, 1995: Awad, 1994, Attawiya et al 1989 and Assaf et al, 2000). The petrofabric study indicates that the metapelites and calc-pelites are highly tectonized. The mafic minerals show shearing, multi-phases stress of deformation and folding (Fig. 11a, b & c).The graphite is highly folded (Fig. 11a) and quartz boudin is usually extending parallel to the foliation planes (Fig.11e). The garnet crystals are affected by syntectonic episode (Fig.11 f).

These rocks are intruded by biotite granite and muscovite granites The granitic rocks are sheared, fractured, jointed, deformed, exfoliated and lineated at their contact with metamorphic rocks. The rocks are cut and crossed by a number of pegmatite veins and basic dikes, striking N50° W-S50° E and dip 65° due to NE.

STRUCTURE

Polyphase folding in Nugrus-Sikait area is clearly evidenced not only by the frequent presence of mesoscopic structures of different types attitudes but also by the superimposing and overprinting of these structures. Among these folds, the plunging asymmetric fold (Fig. 7) and chevron folds (Fig. 8) are recognized .In addition to bedding (S_0), two other primary and crenulation foliation surfaces; (S_1 & S_2) reflecting two fold episodes (F_1 & F_2) are recognized. The associated linear structures are numerous and include mineral lineation, long axes of deformed pebbles, boudin axes as well as hinges of mesofolds.

In the present work, identification of the different folding phases that affected the area was approached utilizing the stereographic projection method of analysis using a lower – hemisphere equal–area net (Weiss, 1959; Turmer Weiss, 1963; Ramsay, 1967; Billings 1972 and Davis and Reynolds, 1996) as follow:

1 Thrusting

At W. Sikait the mafic -ultramafic rocks (peridotites, serpentinites and metagabbros) are thrusted over (WNW-ESE) the ophiolitic mélange rocks with an angle of dip 20°-35° due to SSW and NNE (Fig. 3). At the thrust plane small recumbent and tight folds are common. Moreover, the common occurrences of beryl are recorded at the thrust plane between the over thrusting ultramafic rocks and the down thrusting matrix rocks syn-dating the emplacement of the peraluminous granites.

2-Bedding

The beddings are common in the metasediments and matrix of ophiolitic mélange where felsic bands alternate with mafic ones (Figs. 4 & 5). The dip and dip direction of 200 bedding planes (S_o) were measured and plotted on a stereographic projection (Fig. 11). The stereogram shows many distinct maxima. The first two maxima are situated in NW and SE directions, which represent the two limbs of the main macro-folds. The two maxima are aligned along a great circle representing a fold girdle striking N 35° W and dipping 32° towards SW. The normal to this girdle, i.e, the fold axis, strikes N 65° E –S65°W and plunges 58° towards NE. The second two maxima are situated in NE and SW directions, which are aligned along a great circle representing a fold girdle striking N 80° E dipping 30° towards SE. The normal to this girdle, i.e, the fold axis, strikes N10°W – S10°E and plunges 60° towards NW. The third two maxima are situated in NE and SW directions, which are aligned along a great circle representing a fold girdle striking N38°E dipping 40° towards NE. The normal to this girdle, i.e, the fold axis, strikes N 52° W – S52°E and plunges 50° towards NW. The patterns of this diagram suggest that the compressive stresses responsible for the origin of these beddings are acted in different directions.

3-Foliation

A- Primary foliation (S_1)

Two types of cleavage planes are recognized. The first foliation is the penetrative schistosity (S_1), which is nearly parallel to the relics of bedding planes (S_o). The first foliations were measured in the metasediments and matrix. The second one (S_2) is mainly fracture cleavage which appears as a pencil structure which striking N 40° W dipping 28° towards NE .The attitudes of 150 foliation planes (S_1) were measured and plotted on a stereographic projection (Fig. 12). The stereogram shows two maxima which represent the two limbs of the main macrofold. The two maxima are situated in the NE and SW directions and aligned along a great circle representing a fold striking N 45° E and dipping 74° towards NW. The normal to the girdle, i.e. the fold axis, trends S 45° E and plunges 16° towards SE.

B- Secondary foliation (S_2)

At W. Sikait area, the cleavage planes are recognized specially crenulation types in the ophiolitic mélange. Crenulation type (S_2) is locally developed due to crinkling of the pre-existing S_1 surfaces into kinks of few centimeters in amplitude. On a stereogram (Fig.13) the 150 poles to these surfaces form a tight cluster contours, which besides revealing a predominance in the N 45° W trend is suggestive of being apparently unaffected by subsequent fold events.

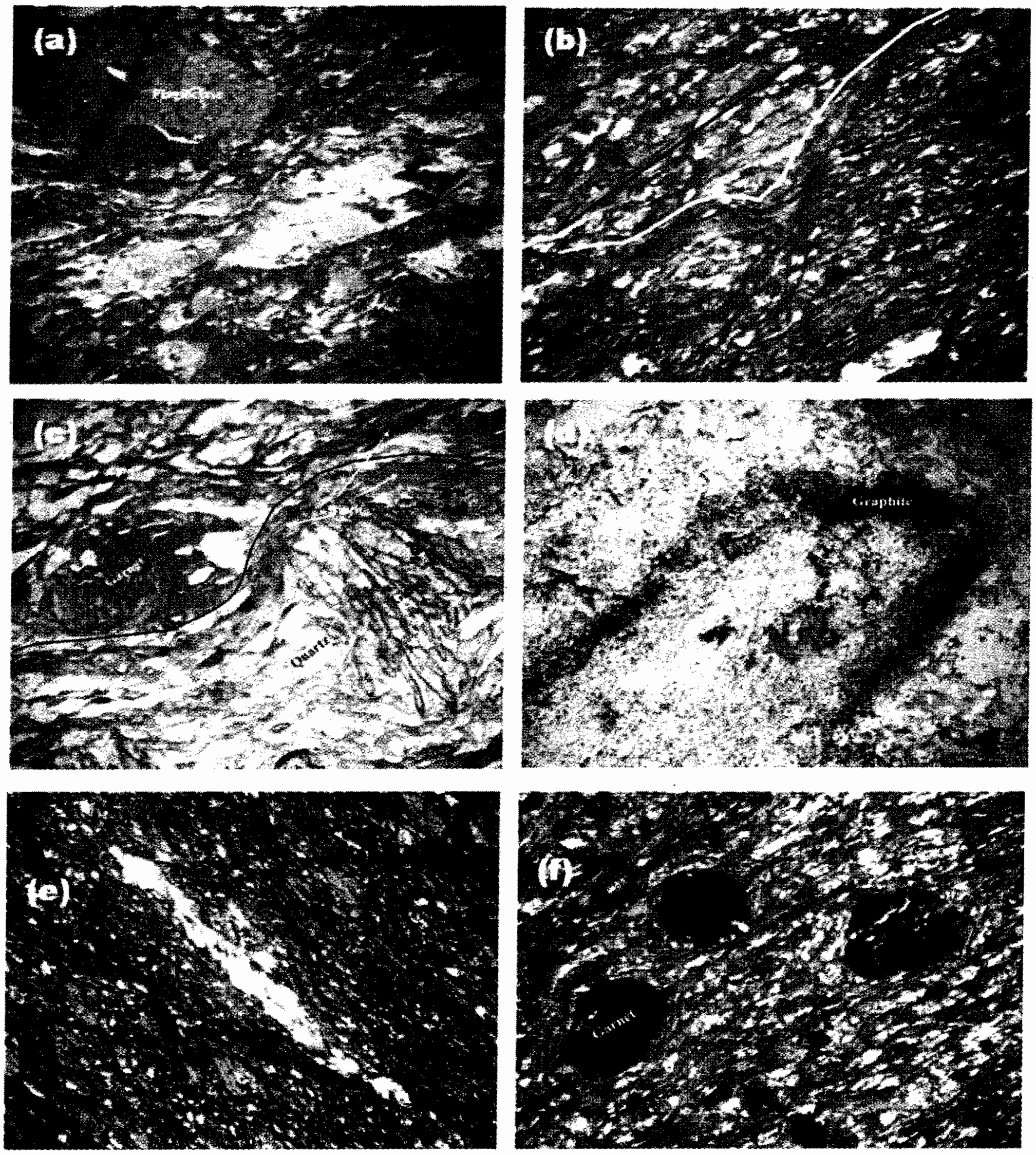

Fig. (3): Photomicrographs in metasediments and matrixes showing : (a) dislocated mafic flakes, (b) folded biotite flakes and deformed garnet, (c) multi-phases stress of deformation and folded biotite flakes, (d) folded graphite, (e) quartz boundins and (f) syntectonic primary garnet. C.N. X 10.

At W.Umm El Kheran area, the cleavage planes are recognized specially crenulation type (S_2). On a stereogram (Fig.14) the 180 poles to these surfaces form tight cluster contours, which besides revealing a predominance in the western trend is suggestive of being apparently unaffected by subsequent fold events.

At Umm Baanib area, the cleavage planes are recognized specially crenulation type (S_2), On stereogram (Fig.15) the 150 poles of these surfaces form a tight cluster, which besides revealing a predominance in the SW trend is suggestive of being apparently unaffected by subsequent fold events.

At Umm Addebaa area, the foliation is a penetrative schistosity (S_1). The dip and dip direction of 150 foliation planes was measured and plotted on a stereograph projection (Fig. 16). The 150 poles of these surfaces form a tight cluster, which besides revealing predominance in the SW trend is suggestive of being apparently unaffected by subsequent fold events.

4-Folding

Polyphase folding in the metamorphic rocks is clearly evidenced not only by the frequent presence of mesoscopic structures of different types and attitudes but also by the superimposing and overprinting of these structures (Fig. 7).

Large and small-scale folds are observed in the study area with different attitudes. At Sikait I exposure; the axes of the folds plunging 34° due to NW direction. At Umm El Kheran exposure; the axes of these folds plunging 37° due to NE direction. At Umm Addebaa exposure; the axis of the fold, is plunging gently towards E-direction.

5-Boudinage

Boudinage is a structure resulted during the stretching of competent layers or veins by considerable thickness of incompetent rocks of metasediments due to ductility contrast (Ramberg, 1955; Ramsay, 1967; Stromgard, 1973; Sanderson, 1974; Smith, 1975; and Ramsay and Huber, 1983). The separate segments are called boudins and the structure is called boudinage. At Umm Seleimat exposure, there are boudins within the NW-SE fault zone. They are composed of competent quartz veins embedded in the matrix (Fig. 3e). The boudins are lenticular in shape, with width ranges from 10 to 20 cm. and the thickness ranges from 1 to 2.5 cm. The width thickness ratio of the boudins is high indicating a high stretching state. The axis of the boudins is plunging 25° towards the NW.

6-Faulting and fracturing

Strike – slip faults are common in the study area. W. Umm Seleimat is affected by right and left lateral-strike slip faults. Most of the observed faults have strike-slip component of motion. The downstream of W. Sikait (NW-SE) is considered as a left lateral–strike slip fault. At Umm El Kheran, most of the strike-slip faults are abundant with marked striation striking E-W (Fig. 2).

CONCLUSION

- The exposed rocks are mafic–ultramafic rocks, ophiolitic mélange, metasediments, granitic rocks and post granite dykes and veins. Thrusting is the oldest structural phase in the study area, where Nugrus thrust is considered as a major thrust with many minor thrust faults. The presence of more than one type of cleavage planes (S1, &S2), as well as the presence of kink bands and crenulations cleavages, may indicate more than one deformational events were affecting the study area.

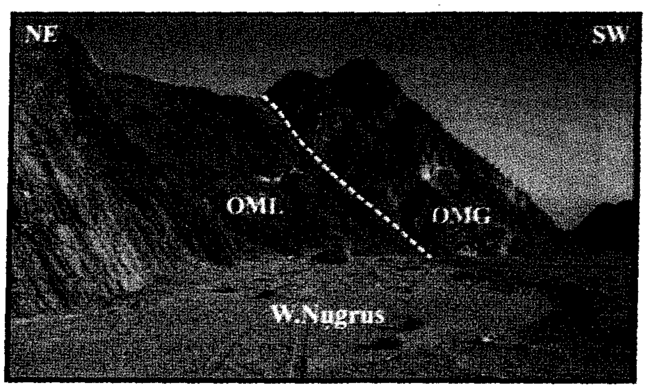

Fig. (3): View showing ophiolitic metagabbros (OMG) thrusted over ophiolitic mélange (OML) with steep thrust contact, W.Nugrus.

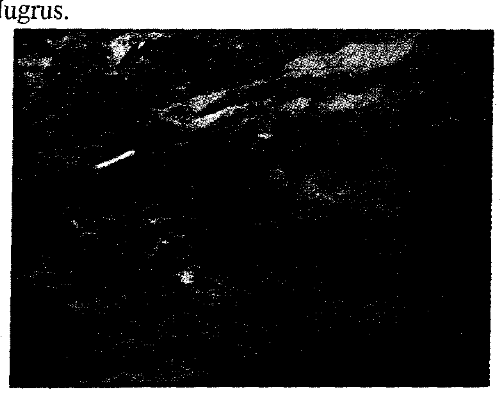

Fig. (4): View showing thin layering in schist, W. Sikait.

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التطور البنائي لمنطقة وادي نجرس – سكيت ، جنوب الصحراء الشرقية – مصر

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المستخلص

تغطى منطقة وادي نجرس – سكيت صخور مكونة من ما فيه إلى فوق ما فيه والميلانج الافيولتى – صخور رسوبية متحولة وصخور جرانيتية حديثة وقواطع وعروق. وتشمل المنطقة على الصخور الافيوليتية وصخور تجمعات القوس مفصولة بصخور الميلانج التكتونى، وتشمل العناصر التركيبية فى المنطقة: الصدوع، الطى، التورق، التطبق، الصدوع والكسور.

التدسر هو الحالة التركيبية الأقدم في منطقة الدراسة ويعتبر داسر نجرس هو الداسر الرئيسي في المنطقة بالإضافة للعديد من الدسر الثانوية. وقد تم التعرف على أكثر من حالة من التشوه. كما أن وجود أكثر من نوع من مستويات التورق (S_1&S_2) قد يدل على أن المنطقة قد تأثرت بأكثر من حدث تشوهي.

وقد اتضح من تحليل العناصر التركيبية المختلفة ومن تواجد الدسرين أن المنطقة تعرضت على الأقل لمرحلتين تكتونيتين (ط١ وط٢)، حيث حدث الطي الأول للصخور القديمة موجهة في إتجاه شمال-جنوب. وبالنسبة للطي الثاني أدى إلى إعادة طي للطيات الأولية في أشكال مضجعة ومائلة حول محور جنوب-شرق.