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Joint fractures on the southern shore of Bellsund, Spitsbergen

ABSTRACT: About 1600 joint fractures were measured in tillites of the Upper Hecla Hoek Formation on the southern shore of Bellsund. Measurements were collected in 12 areas between the Renardbreen and Tjörndalen. Ray diagrams and contour diagrams of joint fractures, and contour diagrams of joint fractures after rotation to pre-folding position were made for each area. The preliminary analysis of diagrams indicates 2 conjugated joint sets: *ca.* 60°—120° and 0°—30°. This joint system is probably older than folding and was originated under ENE—WSW to NE—SW stress.

Key words: Arctic, Spitsbergen, tectonics, joint fractures.

Introduction

During the expedition of the Maria Curie-Skłodowska University of Lublin in summer 1987, about 1600 joint fractures were measured at the southern shore of Bellsund between the Renard Glacier (Renardbreen) and Tjörn Valley (Tjörndalen). Measurements were collected in 12 areas (Fig. 1), all in folded tillites of the Upper Hecla Hoek Formation (Flood, Nagy and Winsnes 1971). Distances between the measurement areas varied from 0.7 km to 2.0 km. In each area 100—200 joint fractures and 2—20 bedding planes (sometimes very unclear in tillites) were measured.

Diagrams

Ray diagrams of joint fracture strikes (Fig. 1) made for 12 measurement areas show a great variety of joint patterns (Ozimkowski 1988). Contour diagrams of poles to joint fracture planes (Fig. 2) show this variety too —

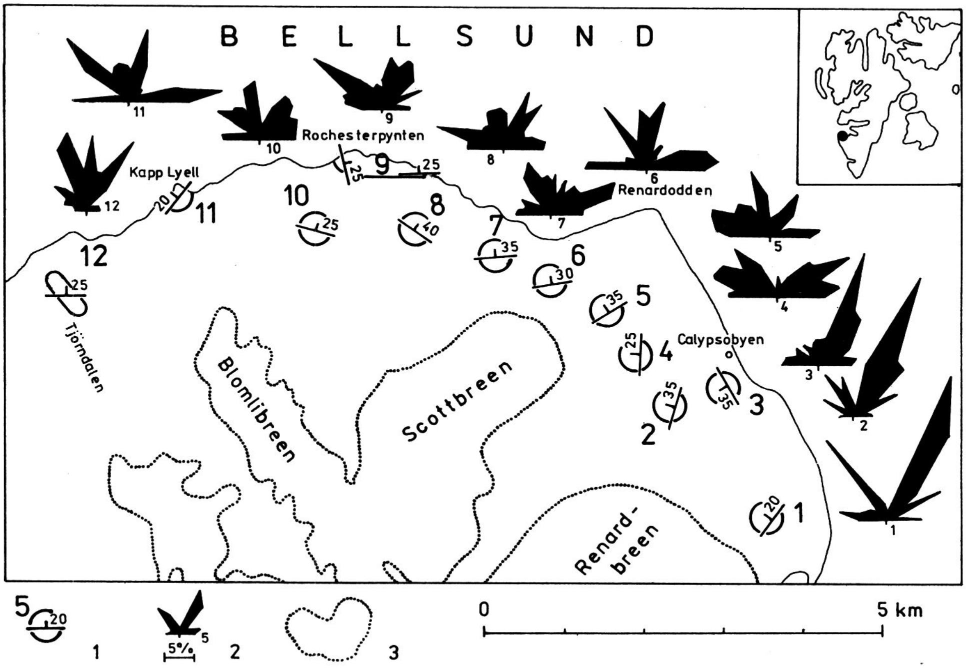

Fig. 1. Joint patterns on the southern shore of Bellsund 1 — measurement area, its number and general dip and strike of bedding planes, 2 — ray diagrams of joint fracture strikes, 3 — glaciers

especially the variety of joint fracture strikes. It can be easily seen in the diagram (Fig. 3) where all joint pattern maximums from 12 areas were put together.

Relationship between joints and bedding planes at contour diagrams (Fig. 2) suggests that joints are generally almost perpendicular to bedding planes (*i.e.* joints are cathetal). It means that joints are of pre- or syn-folding origin (Jaroszewski 1972), and thus "unfolding" of bedding planes together with associated joint fractures may simplify the variety of joint patterns. For this purpose every measured bedding plane was rotated to a horizontal position and simultaneously with it, joint fractures associated with this bedding plane were rotated to its pre-folding position. Then 12 contour diagrams of "rotated" joint fractures were prepared (Fig. 4).

Joint sets

Contour diagrams of "rotated" joint fractures (Fig. 4) show a smaller variety of joint patterns than diagrams of joint fractures before rotation (Fig. 2). Maximums of "rotated" joint patterns (Fig. 4) put together in one

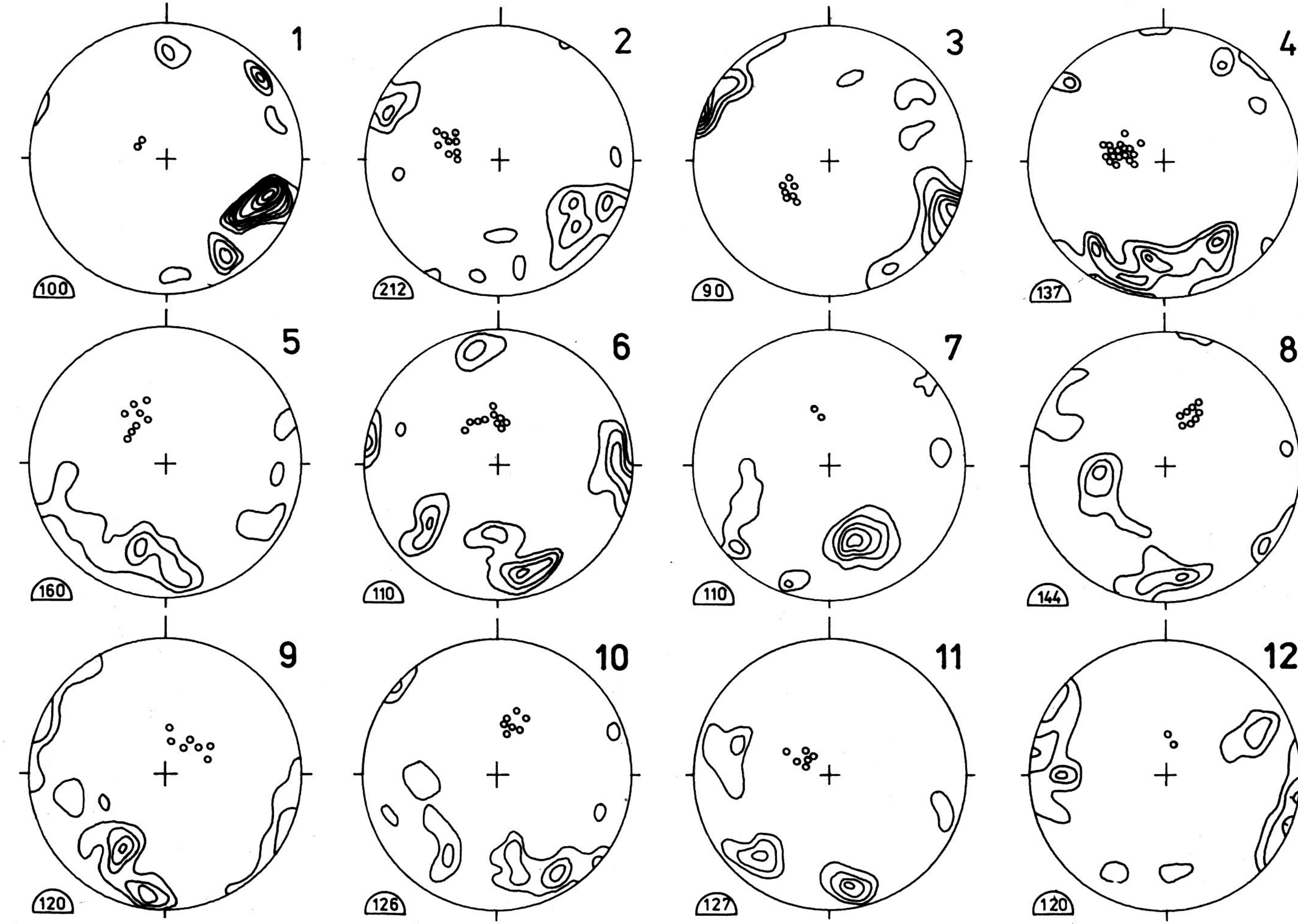

Fig. 2. Contour diagrams of joint fractures (contour lines every 2%) and "scatter" diagrams of bedding planes (small circles) in 12 measurement areas; projection of poles to planes on the upper hemisphere; number inside the small semicircle is the number of measurements of joint fractures

diagram (Fig. 5) are gathered in two groups corresponding to two joint sets:
— "A" — relatively varied (strikes *ca.* 60°—120°), and
— "B" — more limited (strikes *ca.* 0°—30°).

In 5 measurement areas only a single joint set was well developed: A in the areas 4, 5, 7, 11 and B in the area 3, while the second joint set was scant or even absent (*e.g.* joint set B in the area 7: see diagram 7 at Fig. 4).

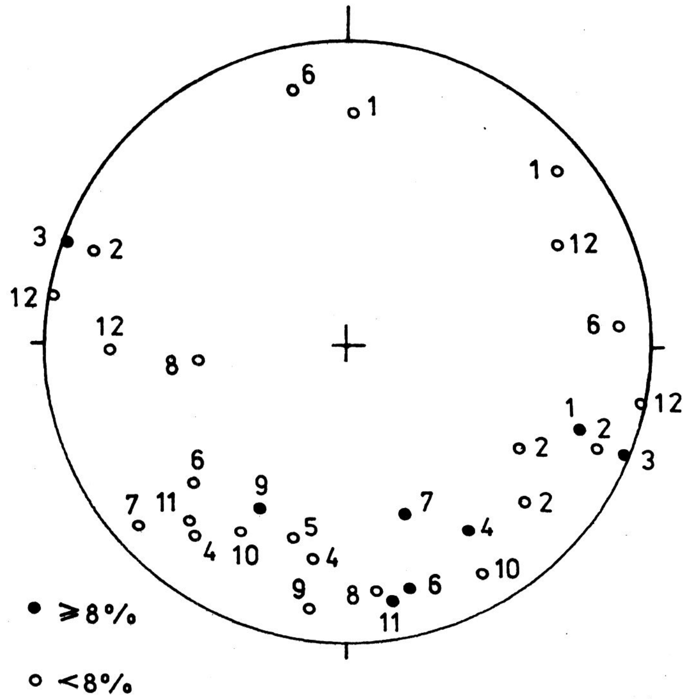

Fig. 3. Maximums of joint patterns from 12 measurement areas; projection as at Fig. 2; small numbers mean measurement areas

In other 7 areas at least two maximums of joint fractures of the joint sets A and B could be easily identified. In some diagrams two or even three maximums of a joint set, A or B, were present (*e.g.* diagrams 6, 10, 12 in Fig. 4).

After rotation of bedding planes to a horizontal position only *ca.* 30% of maximums of joint fractures were strictly vertical (Fig. 5). It means that the joint was not precisely cathetal, maybe due to earlier (pre-jointing) phase of folding or, because of possible errors in measurements of usually very unclear bedding planes in tillites. Because of this, all possible lines of the intersection between A and B "rotated" joint sets are not exactly vertical (Fig. 6).

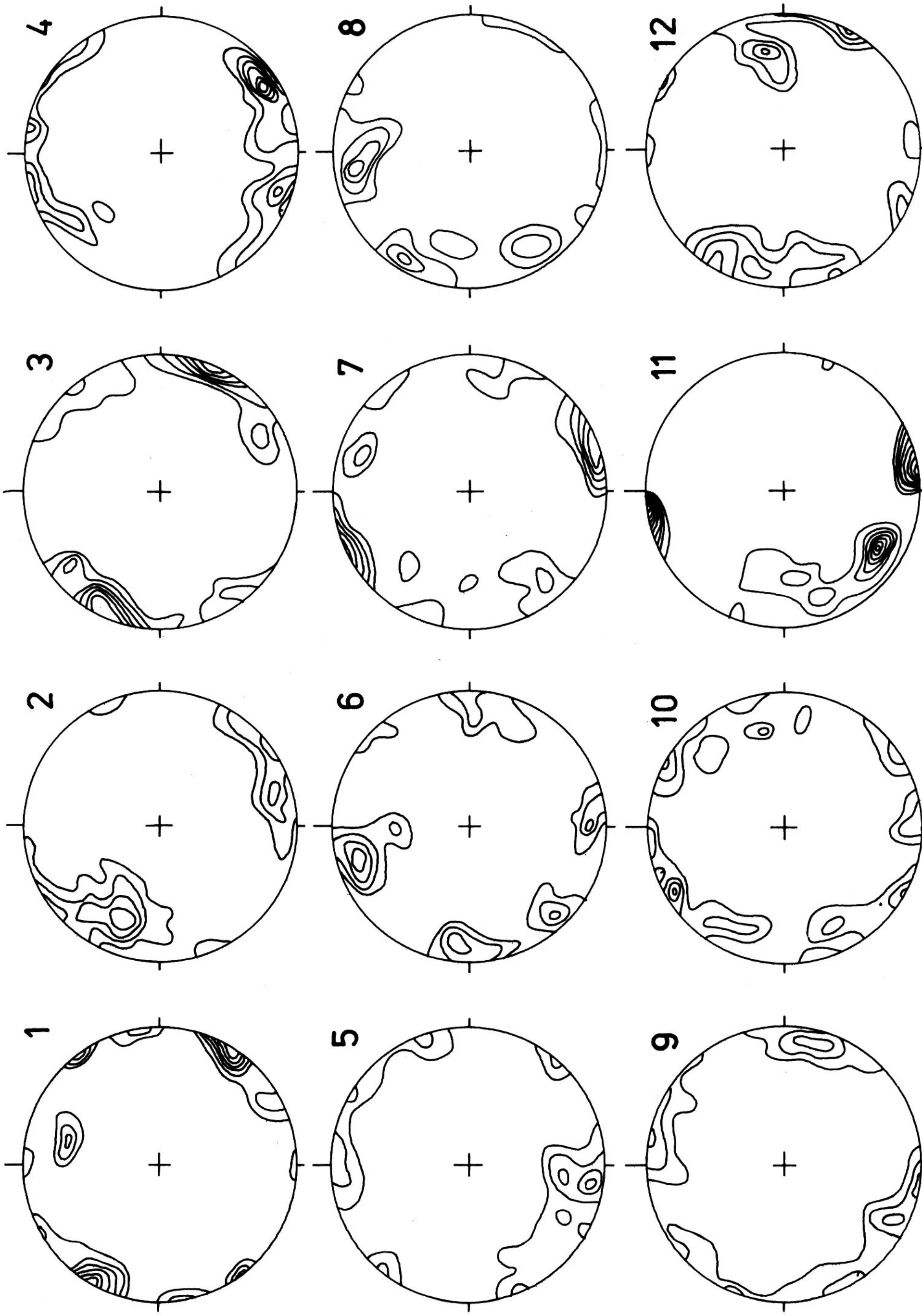

Fig. 4. Contour diagrams of joint fractures rotated to pre-folding position; projection and contour lines as at Fig. 2

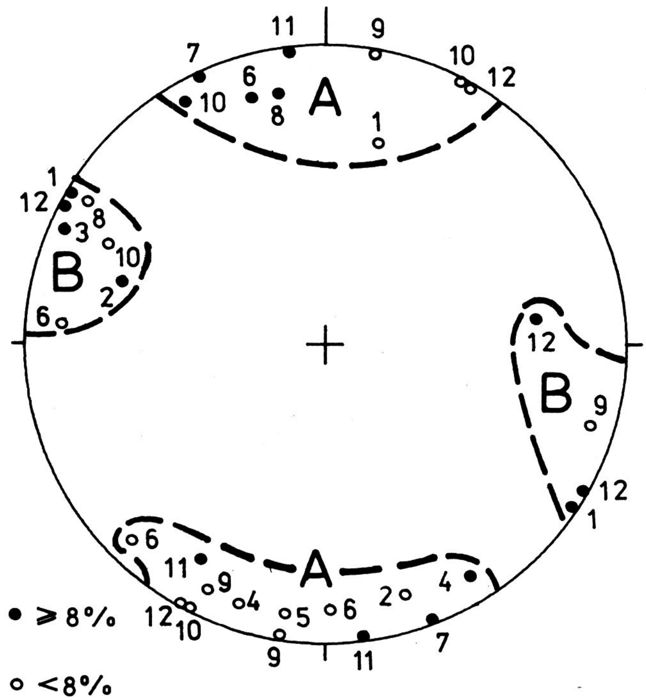

Fig. 5. Maximums of joint patterns after rotation of joint fractures to pre-folding position; A and B means joint sets, projection as at Fig. 2

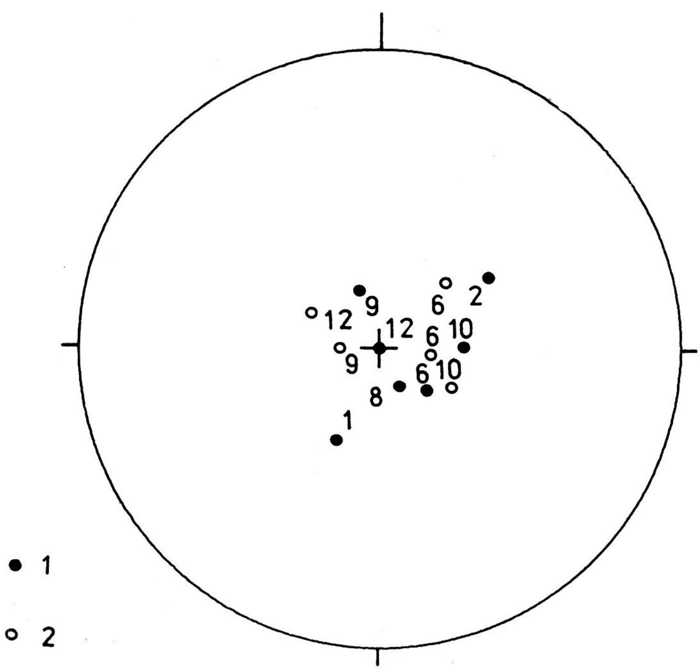

Fig. 6. Lines of intersection between A and B joint sets after rotation of joint fractures to pre-folding position 1 — intersection of main joint sets (8% and more), 2 — intersection of other joint sets (less than 8%); projection on the upper hemisphere

Direction of maximum compression

Interfacial angles between joint sets A and B are different in different areas, but generally are acute (40 —85). The joint sets A and B seem therefore to belong to a system of conjugated joints and so, the bissection line of acute angle between joint sets A and B indicates a direction of maximum compression during the origin of joints (Jaroszewski 1972). The diagram of all possible bissection lines of acute angles between two joint sets shows a general direction of maximum compression close to NE—SW (Fig. 7).

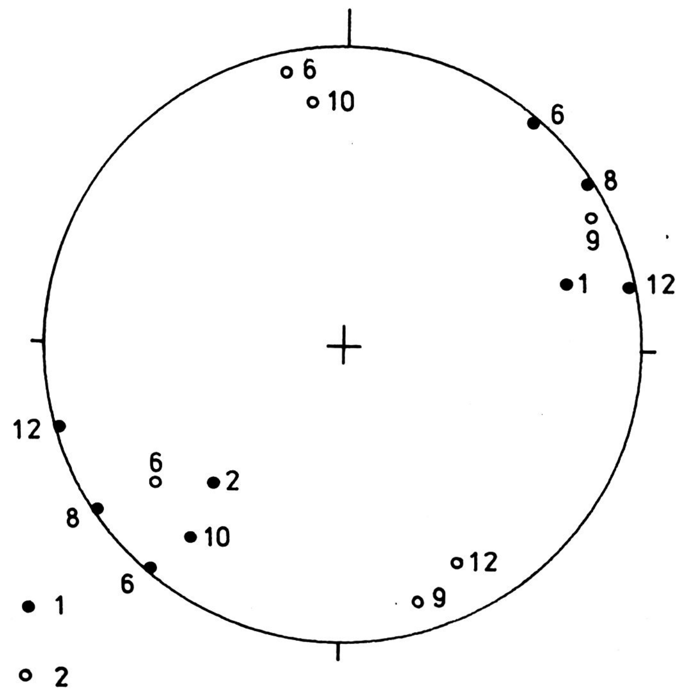

Fig. 7. Bissection lines of acute angles between joint sets A and B; for explanations see Fig. 6

Lines of intersection between conjugated joint sets seem to have been primarily vertical (Mastella 1988). Because of this, lines of intersection between A and B joint sets (Fig. 6) were rotated to a vertical position, together with associated bissection lines of acute angles between joint sets (Fig. 7) and corresponding maximums of both joints sets (Figs 4—5). In this way, the most probable pattern of maximum compression directions during the origin of jointing was reconstructed (Fig. 8).

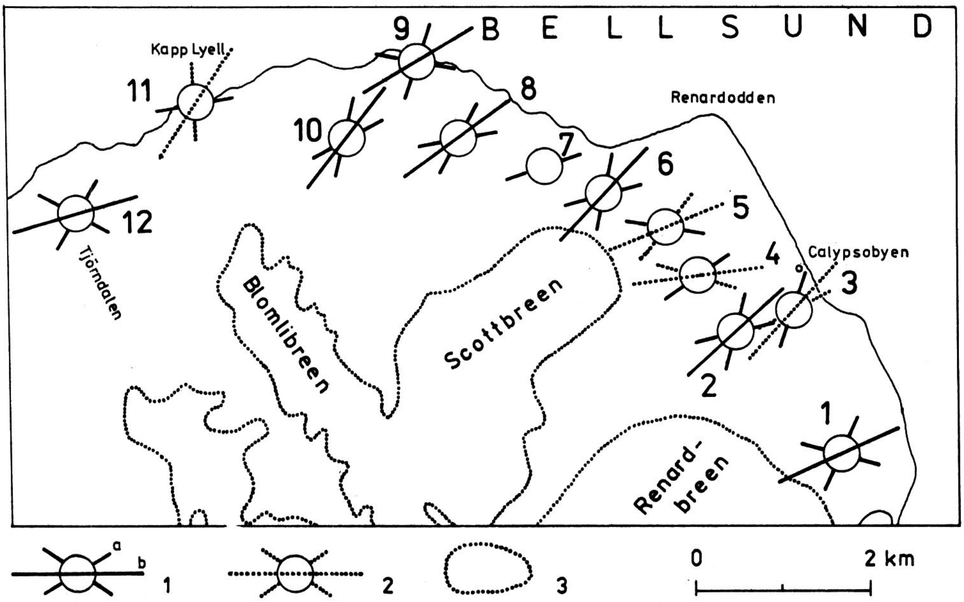

Fig. 8. Most probable directions of maximum compression during the origin of a joint system. 1 — measurement areas with well-developed joint sets (a) and direction of compression (b), 2 — other joint sets and probable direction of compression, 3 — glaciers

Conclusions

Joint pattern in tillites on the southern shore of Bellsund was probably originated under ENE—WSW to NE—SW compression. This direction of compression corresponds with general direction of the fold system in this area (Flood, Nagy and Winsnes 1971), though joints are probably of pre--folding origin. Some deviations of joint sets and directions of maximum compression (see Fig. 8) could be caused by lithological differences within the tillites or by the later influence of younger faults.

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Streszczenie

Latem 1987 r., podczas wyprawy UMCS, zebrano blisko 1600 pomiarów spękań ciosowych w sfałdowanych tyllitach formacji Hecla Hoek na południowym wybrzeżu Bellsundu. Na badanym obszarze wydzielono 12 rejonów odległych od siebie o 0,7—2,0 km, w których pomierzono po 100—200 spękań ciosowych oraz 2—20 położeń warstw.

Dla wszystkich 12 rejonów sporządzono diagramy rozetowe biegów powierzchni spękań ciosowych (fig. 1), oraz diagramy konturowe, uwzględniające także ich upady (fig. 2). Maksima spękań ciosowych z poszczególnych diagramów konturowych naniesiono na diagram zbiorczy (fig. 3), który nie wykazuje wyraźnego ich uporządkowania.

Wzajemny stosunek położeń warstw i spękań ciosowych (fig. 2) przemawia za prostopadłością ciosu do uławicenia (katetalnością ciosu), która świadczy o jego przedfałdowym założeniu. Wyeliminowanie wpływu zafałdowania warstw powinno zatem uporządkować obraz ciosu. Wykonano więc diagramy konturowe spękań ciosowych po rotacji warstw w których spękania te pomierzono do poziomu (fig. 4). Diagram zbiorczy maksimów zrotowanych spękań ciosowych (fig. 5) wskazuje na istnienie 2 zespołów ciosu — "A", w dużym przybliżeniu równoleżnikowego (ok. 60°—120°), oraz "B" — zbliżonego do NNE—SSW (ok. 0°—30°). Zespoły ciosu A i B na ogół nie były jednak dokładnie katetalne, toteż krawędzie ich przecięcia były jedynie zbliżone do pionowych (fig. 6).

Zespoły ciosu A i B na poszczególnych diagramach przecinają się pod kątami różnymi od kąta prostego. Mogłoby to przemawiać za tym, że są to 2 sprzężone zespoły ciosu ze ścinania — wówczas dwusieczna kąta ostrego wyznaczałaby kierunek maksymalnego nacisku. Naniesione na zbiorczy diagram dwusieczne kątów ostrych (fig. 7) wskazują na generalny kierunek nacisków zbliżony do NE—SW.

Rotując do pionu krawędzie przecięcia zespołów ciosu A i B, a wraz z nimi dwusieczne kątów ostrych, odtworzono prawdopodobne kierunki maksymalnych nacisków w czasie zakładania ciosu (fig. 8). Były to naciski od NE—SW do ENE—WSW, czyli zgodne z ogólnym przebiegiem struktur fałdowych w tym rejonie (tzn. prostopadłe do nich).

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