STRUCTURAL ANALYSIS OF DEFORMED EARLY LINEATIONS IN BLACK QUARTZITES FROM THE CENTRAL BADAJOZ-CÓRDOBA SHEAR ZONE (IBERIAN VARISCAN FOLD BELT)

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RESUMEN

En el presente trabajo se lleva a cabo el análisis estructural detallado de un área reducida del sector central del Corredor Blastomilonítico de Badajoz-Córdoba en la cual afloran cuarcitas negras sobre las que se disponen lineaciones de estiramiento deformadas por pliegues posteriores. Se ha podido evidenciar el carácter inhomogéneo de los mecanismos de plegamiento responsables de la deformación superpuesta, los cuales tipifican una zona de cizalla dúctil. Los mecanismos citados son el resultado de la interacción de procesos como *"flexural slip"*, cizalla simple heterogénea, aplastamiento y evolución estructural en el curso de la deformación progresiva. La intensidad de estos procesos es suficiente para reorientar y transponer casi totalmente las estructuras del episodio deformacional previo (esquistosidad milonítica y lineación de estiramiento asociada). Desde el punto de vista cinemático se establece que la esquistosidad deformada correspondía inicialmente a una estructura planar buzante al SE que contenía lineaciones de orientación N-S. La deformación superpuesta es el resultado del emplazamiento hacia el SSW de la unidad tectónica que contiene a las cuarcitas. Estos resultados son correlacionables con los obtenidos para otros sectores del Corredor Blastomilonítico y otras grandes unidades alóctonas de la Zona de Ossa-Morena, y se interpretan como resultado de la actuación de mecanismos y procesos de deformación progresiva en régimen transpresivo.

Palabras clave: Lineaciones, plegamiento, transpresión, Zona de Cizalla de Badajoz-Córdoba, Ossa-Morena.

ABSTRACT

In the present work we deal with a detailed structural analysis of a small area from the central Badajoz-Córdoba Shear Zone. In this area, black quartzites containing deformed stretching lineations crop out. The inhomogeneous character of the folding mechanism recorded during the second deformacion and tipifying a ductile shear zone has been evidenced here. The forementioned mechanisms are the result of an interaction between flexural slip, inhomogeneous simple shear, flattening and the development of structures during progressive deformation. These processes are intense enough to reorientate and remove almost completely previous structures (mylonitic foliation and stretching lineation). From a kinematic point of view, the deformed foliation was an initially southeastwards dipping planar surface containing a N-S stretching lineation. The superimposed deformation is the result of the SSW directed emplacement of the tectonic unit containing the black quartzites. These results may be correlated with others from both the Badajoz-Córdoba Shear Zone and the main allochthonous units from the Ossa-Morena Zone, and are here interpreted as a consequence of progressive deformation in a transpressive regime.

Key words: Lineations, folding, transpression, Badajoz-Córdoba Shear Zone, Ossa-Morena.

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Abalos, B. y Eguiluz, L. (1989): Análisis estructural de lineaciones deformadas sobre cuarcitas negras de la parte central de la Zona de Cizalla de Badajoz-Córdoba (Macizo Hercínico Ibérico). *Rev. Soc. Geol. España,* 2: 95-102.

1. INTRODUCTION.

In recent years many authors have described the progressive generation and evolution of structures within ductile shear zones (Ramsay and Graham, 1970; Coward, 1976; Simpson, 1983). From them, a special account has been taken in relation with the generation and development of a mylonitic foliation from an unfoliated medium, the differentiation of S and C planes and the progressive decrease of the angle between them with shearing, the generation of shear lenses due to the connection of diversely oriented shear surfaces, and the recognition of folds with rotated fold-axes and sheath folds (Carreras *et al.,* 1977; Quinquis *et al.,* 1978; Minnigh, 1979; Cobbold and Quinquis, 1980; Ramsay, 1980). Moreover, within many ductile shear zones, the structural history involves a repeated deformation of relatively early structures and the progressive development of new structures as a consequence of an unique deformational event.

In the present work we deal with the structural analysis of early lineations deformed by later folds. The patterns of deformed lineations obtained may be classified in some different ways on the basis of the nature of the spatial variation between early lineations and second phase fold-axes (Ghosh and Chatterjee, 1985), being the latter shear folds, parallel folds or folds diversely affected by flattening. The deformed lineations acquire spatial arrangements which form is the result of the final strain-state attained by the deformed surfaces that contain them. As a consequence of this, the deformational history of folds may be deciphered from the study of the patterns of deformed lineations over them and from the geometric disposition of such lineation patterns when the folded surfaces are unrolled (Ramsay, 1967; Ghosh and Chatterjee, 1985; Ghosh and Sengupta, 1987).

When the lineation patterns appear straightened on the unfolded surfaces, a flexural-slip folding mechanism may be inferred. In this case, even the orientation of the initial structures may be deduced. Nevertheless, the linear structures which continue curvilinear on the unfolded surfaces are difficult to use in structural analysis and require a speciall account, as the development of such lineation patterns is controlled by a great number of factors. Within ductile shear zones, where the fold hinges may have suffered high-angle reorientations, the angle between the initial lineation (L1) and the later fold-axis (F) may remain unstable all over the fold surface, then reflecting a combined effect of a flexural slip and an internal strain. The recognition of such complex lineation patterns and their representation is performed here by drawing the lineation hairpins on transparencies covering the folded surfaces, and then unrolling them. In this way, we obtain not only the unfolded surface but also the lineation pattern contained and the angular relations between L1 and F over the fold complete surface. The study is completed with the analysis in stereographic projection of the forementioned lineation hairpins, together with the relations they display with both fold-axes and the shape of the folds (pole figures of the deformed surfaces). According to Ramsay (1967) the geometrical loci displayed by deformed lineations in stereographic projection varies between major circles in the case of heterogeneous simple shear folding mechanisms, and minor circles when buckling and/or flexural slip mechanisms are invloved. The simultaneous or consecutive actuation of these two extreme mechanisms produces a set of intermediate geometrical arrangements in stereographic projection.

2. GEOLOGICAL CONTEXT AND CHARACTERISTICS OF THE STUDIED AREA.

The deformed lineations here concerned with are displayed by black quartzites cropping out in an area of reduced extension located 15 km NW of Hornachos and 7 km WSW of Puebla de la Reina, both localities from the Badajoz Province (southern Spain). Geologically, this area is a part of the NE flank of the Mina Afortunada Gneiss Dome, inmediately to the S of the Hornachos Fault and completely within the so-called "Corredor Blastomilonítico" (Couloir Blastomilonitique; Laurent, 1974) or Badajoz-Córdoba Shear Zone. The forementioned black quartzites are typical materials in the Upper Proterozoic metapelitic series from the Ossa-Morena, the Black Series (Serie Negra, Alia, 1963; or Montemolín Schist and Amphibolite Series, Eguiluz, 1988). These black quartzites correspond to siliceous chemical-biochemical shallow-water marine deposits (Eguiluz *et al.,* 1984), being composed almost exclusively of quartz and graphite. From the structural point of view, the black quartzites are characterized by the presence of a clear deformational fabric (Abalos *et al.,* 1989). This fabric is evidenced at a mesostructural scale by a mylonitic foliation and a stretching lineation, being common the presence of sheath folds with fold-axes parallel to the stretching lineation, and at a microstructural scale by the presence of typical quartz deformational microstructures and quartz C-axis fabrics (Abalos and Eguiluz, in press).

Folds with fold-axis parallel to stretching lineations are widespread in the field aside the study area, presenting a N160-180E strike and a southwards vergence, related to the emplacement of an important allochthonous unit towards the South. Nowadays, NE of the Mina Afortunada Gneiss Dome (Fig. 1) a group of black quartzites outcrops may be found not only with a different structural strike (almost transverse to the previously mentioned) but also with a particular and complex pattern of folds and deformed lineations. In these

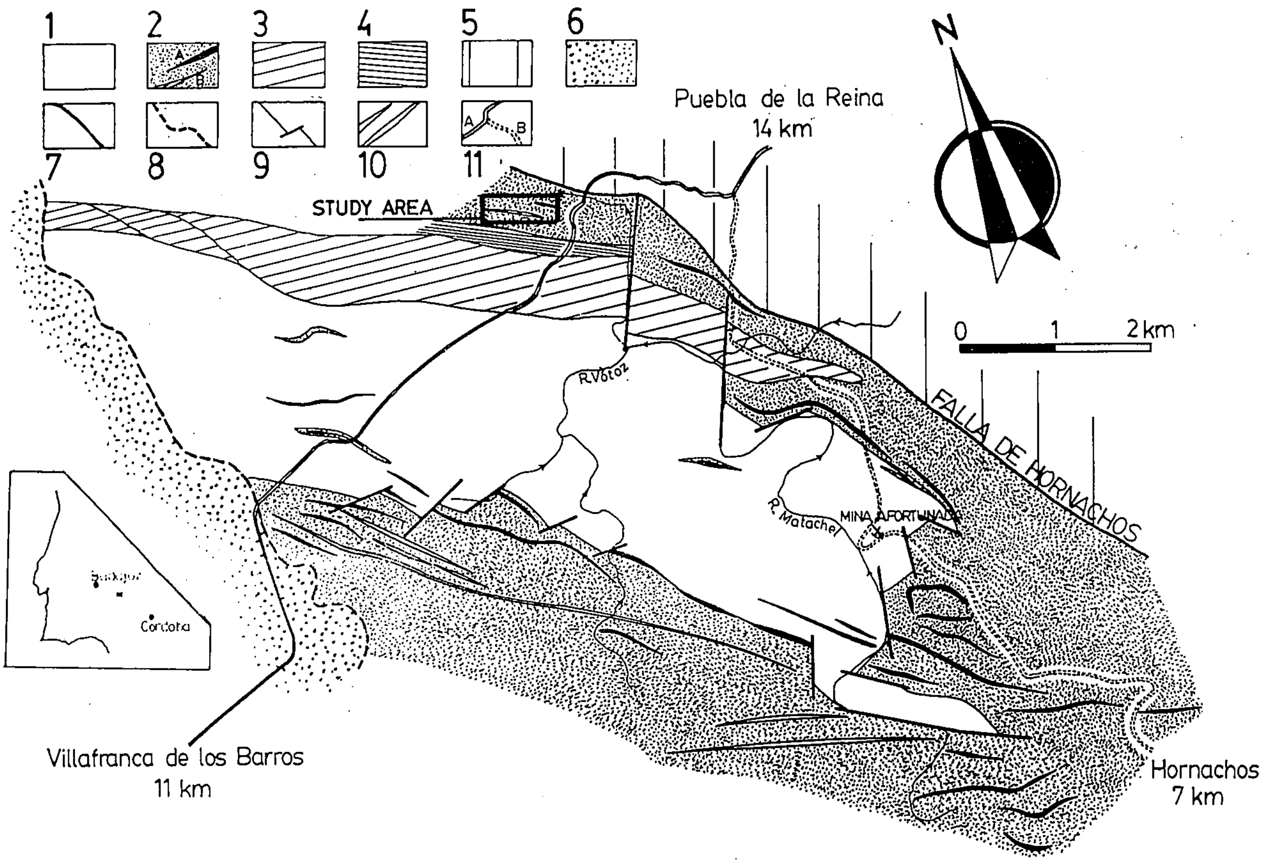

Fig. 1.-Geologic sketch map of the Mina Afortunada Gneiss Dome. 1, orthogneisses and migmatites; 2, Black Series (Upper Proterozoic); 2a, black quartzites; 2b, amphibolites; 3, El Cuartel Amphibolite Unit; 4, schists and stripped quartzites; 5, Obejo-Valsequillo-Puebla de la Reina Dominion; 6, Tertiary and Plio-Quaternary; 7, faults and major mechanical contacts; 8, unconformities; 9, lithological boundaries; 10, diabase dykes; 11a, roads; 11b, rural ways.

Fig. 1.-Esquema geológico del Domo Gneísico de Mina Afortunada. 1, ortogneises y migmatitas; 2, Serie Negra (Proterozoico Superior); 2a, cuarcitas negras; 2b, anfibolitas; 3, Unidad de Anfibolitas del Cuartel; 4, esquistos y cuarcitas tableadas; 5, Dominio de Obejo-Valsequillo-Puebla de la Reina; 6, Terciario y Plio-Cuaternario discordantes; 7, fallas y contactos mecánicos mayores; 8, contactos discordantes; 9, contactos litológicos; 10, diques de diabasas; 11a, carreteras; 11b, pistas rurales.

areas, the folds, of a metric scale, show steeply (locally gently) dipping axial planes, and slightly curved fold-axes with a limited lateral development. The fold-axes parallelize local stretching lineations, although in the proximities of the hinge zones (evenly on the limbs) the mentioned lineations are oblique in a variable degree or transverse to the fold-axes direction. In any case, the local structural trend varies between N-S and NE-SW, clearly oblique and often transverse to the regional NW-SE structural trend of the Badajoz-Córdoba Shear Zone.

3. STRUCTURAL ANALYSIS OF DEFORMED LINEATIONS.

3.1.- Geometrical features of folds.

Four fold types have been distinguished in the field, as shown in Fig. 2. First type folds (Fig. 2a) present horizontal or gently dipping axial surfaces. Fold-axes, as well as the contained lineations, may display bends up to 180°. The folded lineation hairpins may be described as contained in nearly planar surfaces parallel to the fold axial plane. Quartz veins are ubiquitous, and they cross-cut the lineation hairpins at high angles, being slightly deformed as well. From a morphological point of view, these folds are similar to the sheath folds described by Minnigh (1979) or Henderson (1981), although in our case, stretching lineations display a special arrangement.

The second type folds (Fig. 2b) are smaller than the previously described. They arrange sets with a long limb-short limb configuration. Hinge zones present high curvature values, while the angles between limbs are small, about 60°, and the fold-axes are oblique to the enclosed lineations. The angle between fold-axes and lineations varies along the lineation hairpins.

Third type folds (Fig. 2c) show higher values for the angles between limbs, and the curvature of the hinge zone is not very marked, although hinge and limb zones are still distinguishable. Fold-axes are curvilinear, then provoking a gradual passage from orthogonal to

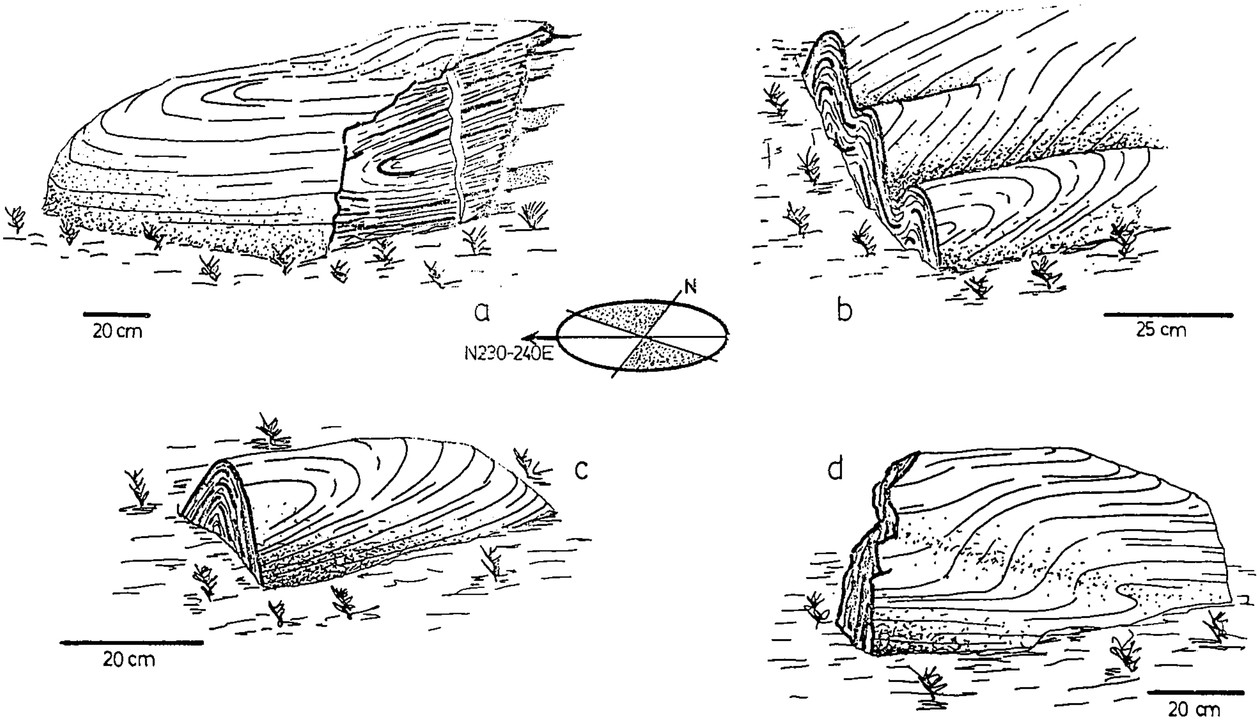

Fig. 2.- Field sketches of folds containing deformed lineations on black quartzites. Labels a, b, c and d correspond to the four fold-types differentiated and described in the text.

Fig. 2.-Esquemas de campo de pliegues con lineaciones deformadas sobre cuarcitas negras. Las etiquetas a, b, c y d corresponden a los cuatro tipos de pliegues diferenciados y descritos en el texto.

parallel lineations along its length. Lineation hairpins may describe complete bends on the limbs.

The folds of the fourth type (Fig. 2d) are characterized by their slightly curvilinear fold-axes. Hinge zone curvatures are much higher than those from the limbs, which could be accounted as slightly wavy surfaces. Angles between limbs are rather small. The enclosed lineations, parallel or orthogonal with the fold-axes along the hinge zones, are sometimes intensely bent on the limbs, the latter holding the same orientation as the fold-axial planes.

3.2. Angular relationships between lineations and fold-axes

The angular relationships between the deformed lineations L1 and the fold-axes F of the folds that contain them (L1-F) are schematized in Fig. 3, following Ghosh and Chatterjee's (1985) representations. In any case, the first characteristic to enhance is that lineation hairpins remain curvilinear on the unfolded surfaces that contain them. From the point of view of the L1-F relations, three types of situations may be differentiated:

— L1 and F are almost orthogonal all over the hinge zones or display constant obliquities (Fig. 3a).

— L1 and F are oblique with fair variations in the angles between them (partly Figs. 3a and 3b).

— L1 and F vary, within an unique hinge, from parallel to oblique and even orthogonal (fig. 3d).

In the case of the first-type relationships, mirror symmetries with respect to the traces of fold axes are common, while rotational symmetries identify the second-type relations and asymmetry characterizes the third. Probably, inhomogeneity at a single-fold scale is the more ubiquitous and remarkable feature of L1-F relations.

According to Ghosh and Chatterjee's (1985) classification, the patterns of deformed lineations here described should be ascribed to types 1, 2a, 3a, 3b, 4 and 5a, in the case of the folds of the first and fourth types previously established, and type 6 patterns, together with local type 1 morphologies, in the case of the folds of the second and third type described above. Anyway, inhomogeneities at the scale of individual folds preclude the establishment of close and univoque relations between fold morphologies and patterns of deformed lineations.

3.3. Structural analysis in stereographic projection.

Under stereographic projection (Fig. 4), the deformed lineations, here considered as a whole, tend to describe major circles, although there exist local but significative variations from this simplified pattern. The girdles defined in this way are clearly NE-SW to ENE-WSW-trending, with maxima close to the SW direction. Individual lineation hairpins appear strongly bent in some areas. Moreover, the representation in the stereographic network of the lineation hairpin sets measured in every folded structure gives rise to a complex and intrincate framework, then resulting in very complex patterns. Nevertheless, these complex dispositions may be interpreted in terms of the relative complexity of both the mechanisms of folding and the initial disposition of foliation and lineations. These complexities come away when the disposition of the folded surfaces pole representations are considered. In this respect, the projections of the folded surfaces are next to major circles, but significative local deviations are present as well.

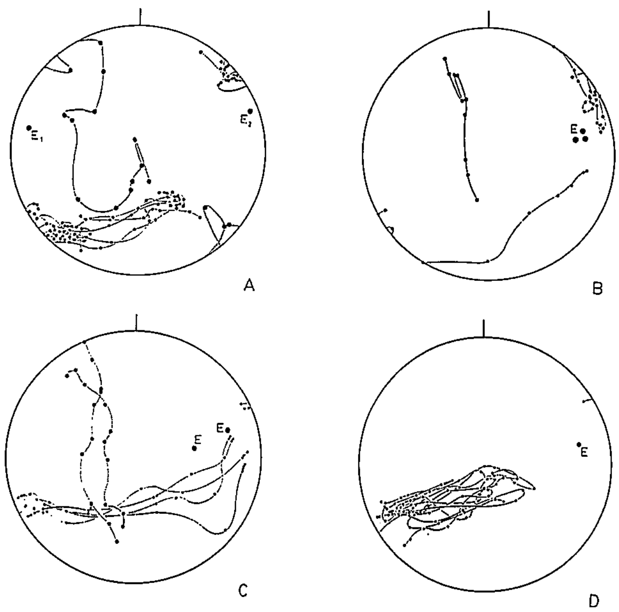

Fig 4.- Projection on the Wulf stereographic network (lower hemisphere) of deformed lineation hairpins (small black points) and poles of the deformed surfaces containing them (intermediate size black points). The bigger black points represent projections of fold-axes for the same structures. Labels A, B, C and D correspond to the four fold-types differenciated in Fig. 2.

Fig. 4.-Proyecciones en la red estereográfica de Wulf (hemisferio inferior) de las lineaciones deformadas (puntos negros de menor tamaño) y de los polos de las superficies plegadas que las contienen (puntos negros de tamaño intermedio). Los puntos negros de mayor tamaño representan los proyecciones de los ejes de los pliegues que contienen las lineaciones deformadas. Las etiquetas A, B, C y D corresponden a los cuatro tipos de pliegues diferenciados en la Fig. 2

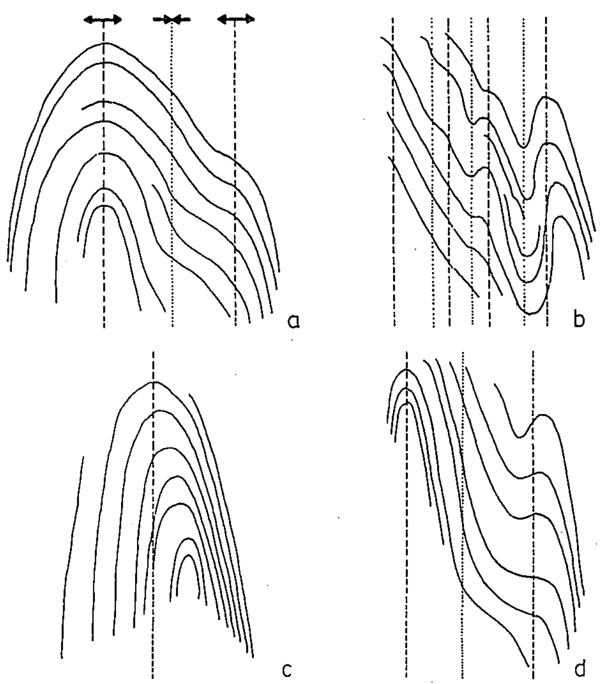

Fig. 3.-Arrangement of the deformed lineations on the folded surfaces that contain them, which are here presented in the unrolled form. The straights made of discontinuous streaks or points represent, respectively, the traces of anticlines and synclines. Labels A, B, C and D correspond to the four fold-types differentiated in Fig. 2.

Fig. 3.-Disposición de las lineaciones deformadas sobre las superficies plegadas que las contienen, las cuales se presentan desplegadas en este esquema. Las rectas formadas por trazos discontinuos o por puntos representan, respectivamente, las trazas de los ejes anticlinales y sinclinales. Las etiquetas A, B, C y D corresponden a los cuatro tipos de pliegues diferenciados en la Fig. 2.

In every case, lineation and foliation distribution areas are almost orthogonal major circles in stereographic projection. In fact, these geometric features remain almost unchanged from a fold-type to another (see Fig. 5), except for a-type folds. In the case of a-type folds, the observed sheath geometry appears reflected by the presence of two orthogonal axial planes (Ax1 and Ax2 in Fig. 5a), being the lineation distribution area next to the great circle where Ax1 is displayed. The long axis of these folds is aproximately contained at an edge of these areas, close to the projection of the regional mylonitic lineation. The folds of the types b, c and d show greater similarities among them than with the previous type. In the three the fold-axis is orthogonal respect the major circle upon which foliation poles plot. Lineation distribution areas display a rough major circle which tends to be close to the position of the fold-axial planes. These major circles are not complete, as there remains a small void area where the fold axis plot.

All these geometric arrangements are here considered as the result of a deformation of early lineations then involved in a second tectonic event which trend, kinematics and sense of displacement is not the same as in the previous one. In the same manner, the intensity of the superimposed deformation is enhanced, as the early structures are completely reoriented and/or transposed to the second event trends.

3.4. On the mechanisms of the superimposed deformation.

According to the considerations and geometrical

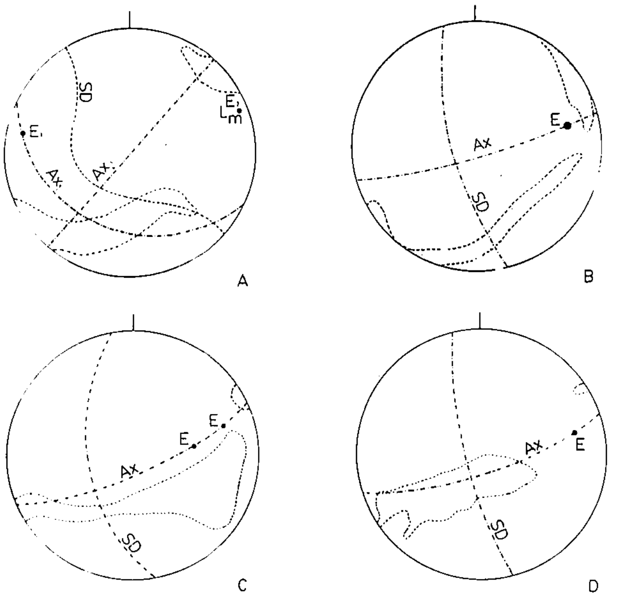

Fig. 5.-Simplified sketches in stereographic projection (Wulf, lower hemisphere) for the geometric relationships between fold-axial planes (Ax), fold-axes (E), place of the foliation poles displayed (SD) and projection areas for deformed lineations (dotted areas). A, B, C and D as in previous figures.

Fig. 5.-Esquemas simplificados en proyección estereográfica (hemisferio inferior de la estereofalsilla de Wulf) de las relaciones geométricas existentes entre los planos axiales (Ax), ejes (E), lugar geométrico donde se proyectan los polos de las superficies plegadas (SD) y áreas donde se proyectan las lineaciones deformadas (áreas punteadas). A, B, C y D como en las figuras anteriores.

models proposed by Ramsay (1967) as a tool to establish the mechanisms of generation of folds from the study of the lineations contained, our field examples become the result of flexural-slip plus- or followed by inhomogeneous simple shearing, or buckling followed by flattening. Ghosh and Chatterjee's (1985) theoretical models point to the same results, although additional information concerning the initial relationships between early lineations and fold-axes is yielded.

These results may be summarized as follows:

— F and L1 are initially oblique, 30-50°, in the case of 3a and 3b patterns, with an evolution from 3a to 3b with progressive deformation.

— Coaxial deformation, F and L1 orthogonal and early lineations parallel to the Z-direction of the second deformation in the case of type-4 patterns; moreover, the X axis of the final strain ellipsoid is greater than the Y axis, indicating large stretching along the fold-axes.

— Tangential longitudinal deformation at the outter arc of buckling folds in the case of type-5a patterns.

— The complex dispositions of type-6 patterns should reflect a progressive migration of hinge zones, which should not remain parallel during progressive deformation, then evolving from hinge zones to limb zones and conversely from limb zones to hinges. These patterns could be the result of the folding of foliation surfaces containing initially curvilinear lineation hairpins as well.

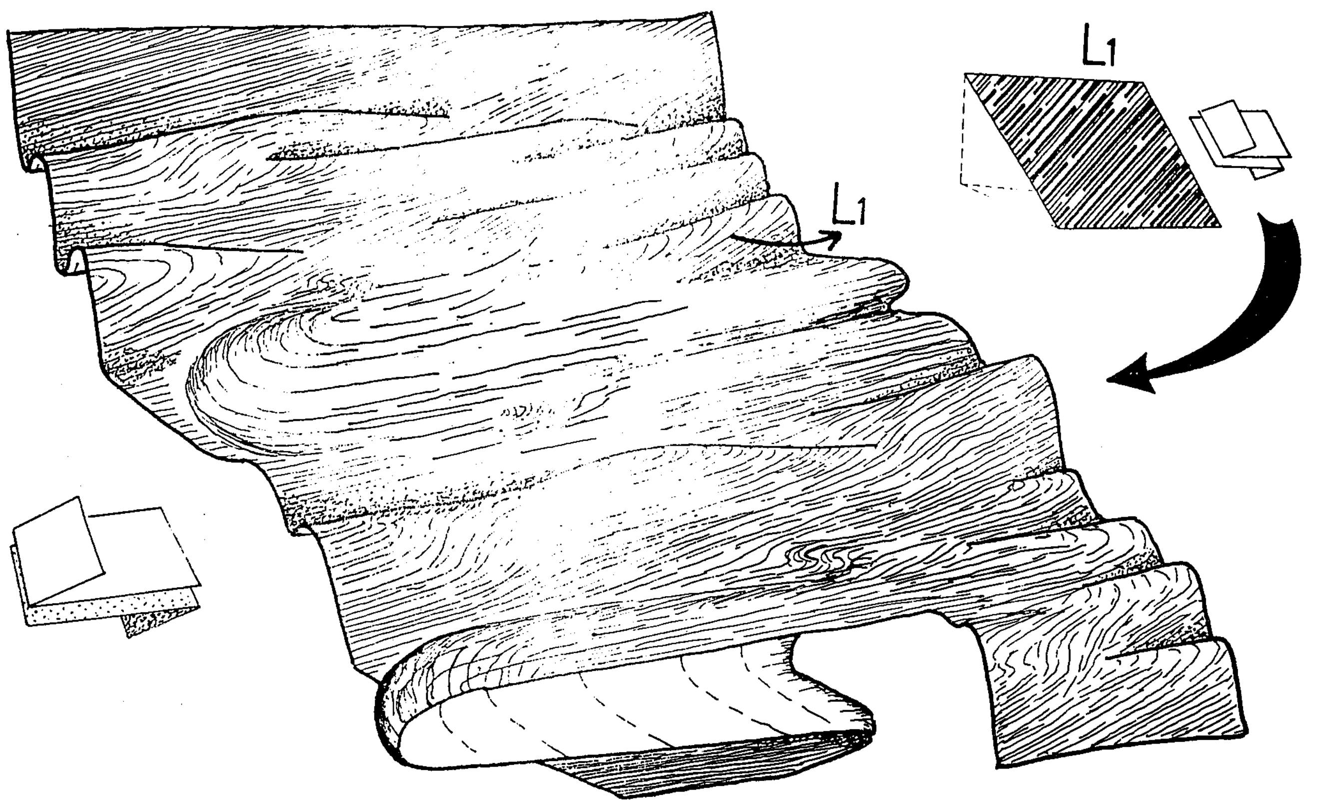

Fig. 6.-Simplified tentative reconstruction for the geometry and orientation of the early structures in relation to the trends of the superimposed deformation (top right) and for the final stage of inhomogeneous folding under a simple shear regime.

Fig. 6.-Reconstrucción tentativa simplificada de la orientación y geometría de las estructuras originales respecto a las directrices de la deformación superpuesta (arriba, a la derecha) y del esquema final de plegamiento heterogéneo en régimen de cizalla simple.

Anyway, all the lineation patterns here studied are characterized by their curvilinear arrangement on the unfolded foliation surfaces. Thus, a choice should be accounted to establish a genetic model comprising two different deformational events or a more or less continuous and extended history of progressive deformation including folding mechanisms such as those which give rise to sheath folds. In fact, it should be pointed that the final results could be attained by means of: a) progressive folding stressing the lineation curvatures on hinge zones while limbs approach planar surfaces, b) the gradual passage from hinges with curved lineations to limbs, or c) the development of minor folds with folded lineations on the limbs of greater folds, then being erased during a subsequent flattening or stretching episode.

4. DISCUSSION AND CONCLUDING REMARKS.

It is obvious from this study the superposition of an heterogeneous folding episode affecting a quartzitic ensemble previously foliated and lineated. The mechanisms of folding are areally variable, thus alternating areas largely affected by flexural slip followed by flattening with areas affected by shearing, buckling, etc. The areas characterized by inhomogeneous simple shear parallel or not to the foliation surfaces are probably the more intensely deformed, recording different stages of progressive deformation partially or totally erased later. This inhomogeneous character of deformation is a typical attribute of ductile shear zones. In the case here presented, the ductile shear zone responsible for the observed structural evolution presents a maximum stretching in a NE-SW direction, with a south west directed movement.

The initial position of foliation and lineations may be obtained from the shape of the geometrical loci and patterns shown by the deformed lineations contained in southeast dipping straightened limbs. In this way, the more successful hypothesis suggests the presence of initially SE-wards dipping foliation surfaces containing aproximatelly N-S stretching lineations. These early structures were probably generated during an intense ductile shearing episode with a S vergence, as it has been evidenced in the neighbouring areas (Mina Afortunada Gneiss Dome; Abalos and Eguiluz, in press). The second deformation determined both the reorientation and transposition of previous structures, giving rise to a complex structural framework (see Fig. 6). These should be the consequence of a SSW-SW-directed emplacement of the tectonic unit containing the black quartzites.

In the Ossa-Morena Zone, such SW-wards directions of tectonic emplacement are just known for the main alloctonous units (mainly from the southern Ossa-Morena). Notwithstanding, they are unknown and uncommon within the Badajoz-Córdoba Shear Zone, where a sinistral sub-vertical shear zone with a variably but gently dipping NW-SE stretching lineation has largely been recognized. These two directions of tectonic transport, NW-SE and NE-SW, are here proposed to be the result of the sinistral strike-slip structural evolution of the Badajoz-Córdoba Shear Zone under a transpressive regime, thus assuming the existence of a transverse shortening accompanying the general wrenching.

REFERENCES

Abalos, B. and Eguiluz, L. (in press.): Structural Geology of the Mina Afortunada Gneiss Dome (Badajoz-Córdoba Shear Zone, SW Spain). *Hercynica.*

Abalos, B., Basterra, R., Cassi, J.M., Eguiluz, L., Pérez de San Román, L. and Tascón, A. (1989): Estudio microestructural y de petrofábrica en cuarcitas negras de bandas de cizalla de la Ossa-Morena (Cabalgamiento de Monesterio y Corredor Blastomilonítico de Badajoz-Córdoba). *Studia Geol. Salmanticensia.* Vol. esp. 4: 83-94.

Alia, M. (1963): Rasgos estructurales de la Baja Extremadura. *Bol. Real Soc. Esp. Hist. Nat.,* 61: 247-262.

Carreras, J., Estrada, A. and White, S. (1977): The effects of folding on the c-axis fabrics of a quartz mylonite. *Tectonophysics:* 39: 3-24.

Cobbold, P.R. and Quinquis, H. (1980): Development of sheath folds in shear regimes. *Jour. Struct. Geol.,* 2: 119-126.

Coward, M.P. (1976): Strain within ductile shear zones. *Tectonophysics,* 34: 3-24.

Eguiluz, L. (1988): *Petrogénesis de rocas ígneas y metamórficas en el Anticlinorio Burguillos-Monesterio, Macizo Ibérico Meridional.* Tesis, Univ. del País Vasco, 694p.

Eguiluz,L., Arriola,A., Garrote,A., Labarca,C. and Sánchez-Carretero,R. (1984): Materiales silico-carbonosos en el Precámbrico de Sierra Morena. *Cuad. Lab. Xeol. Laxe,* 8: 52-81.

Ghosh,S.K. and Chatterjee, A. (1985): Patterns of deformed early lineations over later folds formed by buckling and flattening. *Jour. Struct. Geol.,* 7: 651-666.

Ghosh,S.K. and Sengupta,S. (1987): Progressive development of structures in a ductile shear zone. *Jour. Struct. Geol.,* 9: 277-287.

Henderson, J.R. (1981): Structural analysis of sheath folds with horizontal X-axis, Northeast Canada. *Jour. Struct. Geol.,* 3: 203-210.

Laurent,P. (1974): *Structure et Pétrologie de la Bande Blastomylonitique de Badajoz-Córdoba a l'ouest d'Azuaga.* Thése 3 éme cycle. Univ. Montpellier, 120p.

Minnigh, L.D. (1982): Structural analysis of sheath folds in a meta-chert from the western Italian Alps. *Jour. Struct. Geol.,* 1: 275-282.

Quinquis,H., Audren,C.L., Brun,J.P. and Cobbold,J.P. (1978): Intense progressive shear in the Isle de Groix blueschists and compatibility with subduction or obduction. *Nature,* 273: 43-45.

Ramsay,J.G. (1967): *Folding and Fracturing of Rocks.* Mac

Graw-Hill, New York, 568 p.
Ramsay, J.G. (1980): Shear Zone geometry: a review. *Jour. Struct. Geol.,* 2: 83-89.
Ramsay, J.G. and Graham, R.H. (1970): Strain variations in shear belts. *Can. Jour. Earth Sci.,* 7: 786-813.
Simpson, C. (1983): Strain and shape fabric variation associated with ductile shear zones. *Jour. Struct. Geol.,* 5: 61-72.

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