EUROPEAN SCIENCE FOUNDATION

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PROCEEDINGS

OF THE

FIFTH WORKSHOP

ON THE

EUROPEAN GEOTRAVERSE (EGT) PROJECT

The Iberian Peninsula

Edited by E. Banda and L.A. Mendes-Victor

Published with financial aid

from the

COMMISSION OF THE EUROPEAN COMMUNITIES

November 1988

del Macizo Hesperico. Bea et al. (eds.). Ed. Rueda. 405-412.

SANTA TERESA, I. (1982).
Geometria en profundidad del granito de Orgaz (Toledo), en base a datos gravimetricos. Ms. Thesis. Complutense U., Madrid

SANTA TERESA, I., CARBO, A., CAPOTE, R. CASQUET C. (1983).
Geometria en profundidad del granito de Orgaz en base a datos gravimetricos. Studia Geol. Salmant. 18, 237-250.

SOPEÑA, A., RAMOS, A. (1985).
El final del ciclo hercinico en el Sistema Central Espanol. El Permico. Rev. R. Acad. C. Exact. Fis y Nat. 79, 617-623

UBANELL, A.G. y DOBLAS, M. (EN PRENSA)
Modelos geotectonicos de los diques E-W en el Sistema Central Espanol. Cuad. Lab. Xeol. Laxe.

VIALETTE, Y., BELLIDO, F., FUSTER, J.M. & IBARROLA, E. (1981).
Donnees geochronologiques sur les granites de La Cabrera. Cuad. Geol. Iber. 7, 327-335.

VILLASECA, C. (1985).
Los granitos de la Sierra de Guadarrama. Rev. R. Acad. C. Exact. Fis y Nat. 79, 573-587.

WAARD, D. (1950).
Polnigenetic structures in augengneis of the Sierra de Guadarrama (Spain). Bull. Com. Geol. Finlande 23, 51-66.

EXTENSIONAL TECTONICS AND GRANITE EMPLACEMENT IN THE SPANISH CENTRAL SYSTEM. A DISCUSSION.

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ABSTRACT

The Hercynian compressive events were followed in the eastern Spanish Central System by an important extensional tectonics evolving in space and time during a period of ca. 70 million years. Granites emplacement seems to be related to this extensional activity. Uplift of the inner high-grade areas relative to the low-grade ones along extensional fault-shear zones gave rise to a core complex-like final geometry of this part of the Hercynian basement.

EARLY WORKS

The existence of extensional structures in the eastern part of the Spanish Central System (S.C.S.) is a well known fact. They were first recognized by MARTIN ESCORZA (1977, 1981) in the El Escorial metamorphic area and shortly after by DOBLAS et al.(1983, 1988) in the granitoids of Sierra de San Vicente south of the Gredos massif. More recently HERNANDEZ ENRILE (1987) introduced for the first time the term "core complex" in the region, to refer to the Toledo Migmatite Unit. CAPOTE et al.(1987) referred to all the late-Hercynian extensional activity as the Malagon Episode. GONZALEZ CASADO (1986), GONZALEZ CASADO and CASQUET (1988) and GONZALEZ-LODEIRO et al. (1988) showed that the Berzosa Shear Zone, a compressive shear zone on the east of the S.C, S., that separates the Ollo de Sapo domain from the inner part of the Centro-Iberian Zone was reactivated extensionally under retrograde metamorphic conditions, for the first, or later, for the second. Lastly BERGAMIN et al.(1988) recognized another important fault similar to the Toledo, to the north of the S.C.S.

STRUCTURAL FEATURES

The structural and textural characteristics show that these extensional features range from ductile shear bands to faults with brittle fabrics reflecting a time and space evolving process. In some cases a large part of this evolution can be recognized in a single extensional accident.

The extensional tectonics begins at the end of the third compressive Hercynian phase (D3) recognized in this part of the S.C.S., characterized by backfolding. It is manifested as migmatitic structures of the dyctonitic-crociditic type visible in the quartz-feldspar richer lithologies -the orthogneisses- which are abundant in the deeper high-grade areas of the S.C.S. These structures formerly described by DE WAARD (1950), consist of small extensional bands with a bending of the regional S1-2 foliation accompanied by a strong migmatization (nebulitization) of the sheared zone. The even distribution of these structures all over the region, a predominant E-W trend and the sense of movement to both south and north, suggest that they represent an early stage of an homogeneous N-S extension, that begun when high-grade metamorphic conditions still prevailed at depth. It must be remembered that the metamorphic peak was reached later in the deep regions of the orogen. Thus it is pre and syn-D2 in the low-grade areas, and persists well after D3 in the high-grade ones (CASQUET & NAVIDAD, 1985).

At the other end of deformation style and younger in time we can place important normal faults like the Toledo and Nieva faults (Fig.1). Both faults give rise to an important metamorphic discontinuity as they separate high and low-grade domains on each side. The first correspond to the inner part of the S.C.S. and consist of Lower-Ordovician orthogneisses and Hercynian granitoids. The second are made mostly of slates and quartzites ranging from Upper Precambrian to Lower Paleozoic in age. Both faults display an evolution in time from ductile to brittle structures. In any case its recorded activity took place under retrograde conditions. In the Nieva case it is remarkable the existence of a contact metamorphism probably due to the thermal effect of the hotter block (BERGAMIN et al.1988).

Apart from these extremes other normal shear zones are found such as the San Vicente, Santa Maria de la Alameda and Berzosa zones (Fig.1) inside the metamorphic complex.

Combination of the successive extensional accidents has permitted the uplift of the medium-high grade inner rocks relative to the medium-low-grade ones. Thus the S.C.S. resembles a structure of the core complex type ,as suggested by DOBLAS (1987), extended in a E-W direction and bounded to the north by the Nieva fault and the similar Cruz de Hierro fault, to the south by the Toledo fault and to the east by the Berzosa Shear Zone.

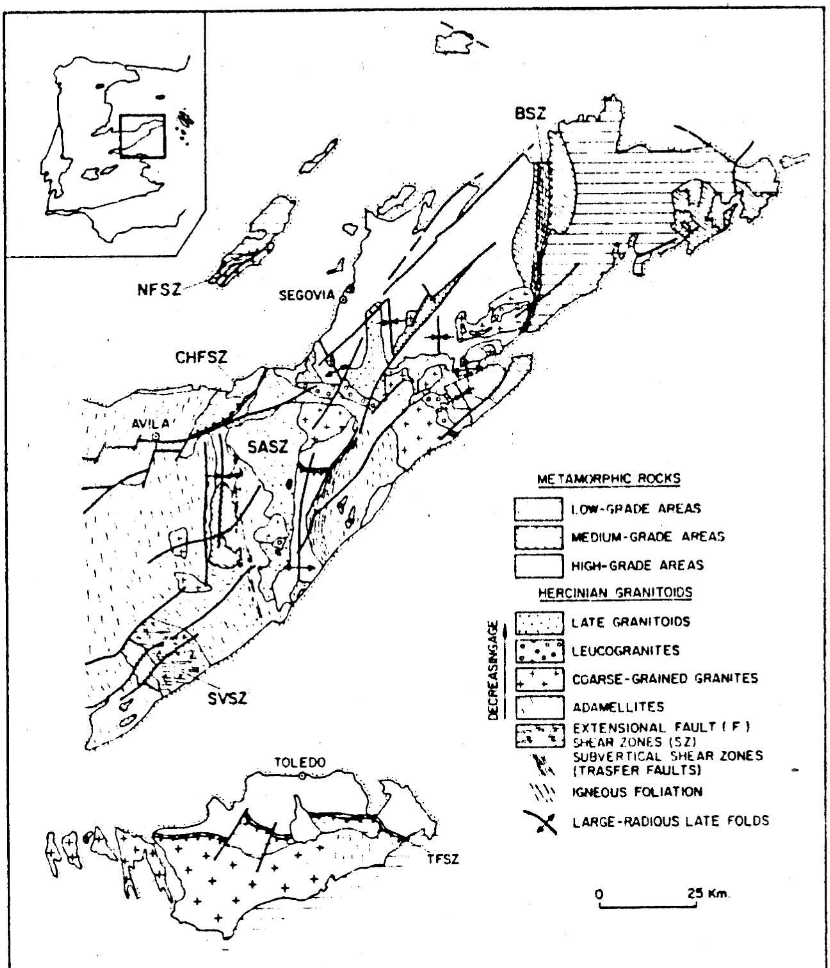

Fig. 1.- Simplified map of the eastern part of the Spanish Central System. NFSZ: Nieva Fault-Shear Zone; BSZ: Berzosa Shear Zone; CHFSZ: Cruz de Hierro Fault-Shear Zone; SASZ: Santa Maria de la Alameda Shear Zone; SVSZ: San Vicente Shear Zone; TFSZ: Toledo Fault-Shear Zone.

GEOPHYSICAL DATA

The two important normal faults of Toledo and Nieva have been studied by gravimetric methods in order to elucidate the fault geometry at depth (SANTA TERESA (1982), SANTA TERESA et al. (1983) and BERGAMIN et al.(1988)). In both cases the models that fit better the data indicate that the dip of the sheared zone, near to 60° at the surface, decreases with depth becoming almost horizontal at ca. 5-7 Km.(Fig2).

The deep seismic refraction studies based on the Caceres-Teruel and Teruel-Toledo profiles, carried out by BANDA et al.(1981), allow certain correlation. Thus BANDA et al.(op.ct.) detect the existence of a low velocity channel (Vp=5.6 Km s-1) at 7-11 Km separating the crystalline basement (6.05-6.15 Km s-1) from an intermediate crust (6.4 Km s-1). This band could correspond to the detachment level of the late-Hercynian extensional accidents.

THE HERCYNIAN GRANITOIDS

They are very abundant in the Sierra del Guadarrama and Gredos (Fig.1). Several compositional groups can be distinguished: adamellites, coarse grained granites and two-mica leucogranites as well as earlier minor intrusions of quartz-diorites and tonalites. From a geochemical point of view the first constitute peraluminous associations and the last are cafemic (BRANDEBOURGER et al.1983;BRANDEBOURGER, 1984;VILLASECA, 1985; and FUSTER & VILLASECA, 1987). These associations are interpreted as a case of orogenic magmatism in a crust thickened by intracontinental collision with participation of the mantle to some extent. To the former associations we should add some granites of a monzonitic affinity (CASILLAS & PEINADO, 1987) that represent a significative change in the chemical evolution of the S.C.S. granitoids.

All these granitoids form intrusive units which are fairly simple in composition, but their mode of emplacement and relationship to the tectonics is at present not fully understood.

After the emplacement of the granitic plutons, an injection under evident brittle conditions of a series of dyke-swarms consisting for the most part of granite-adamellite porphyries, leucogranite porphyries and minor microdiorites takes place. They mostly show an E-W trend and lengths of tens of kilometers (HUERTAS, 1986).

GEOCHRONOLOGY

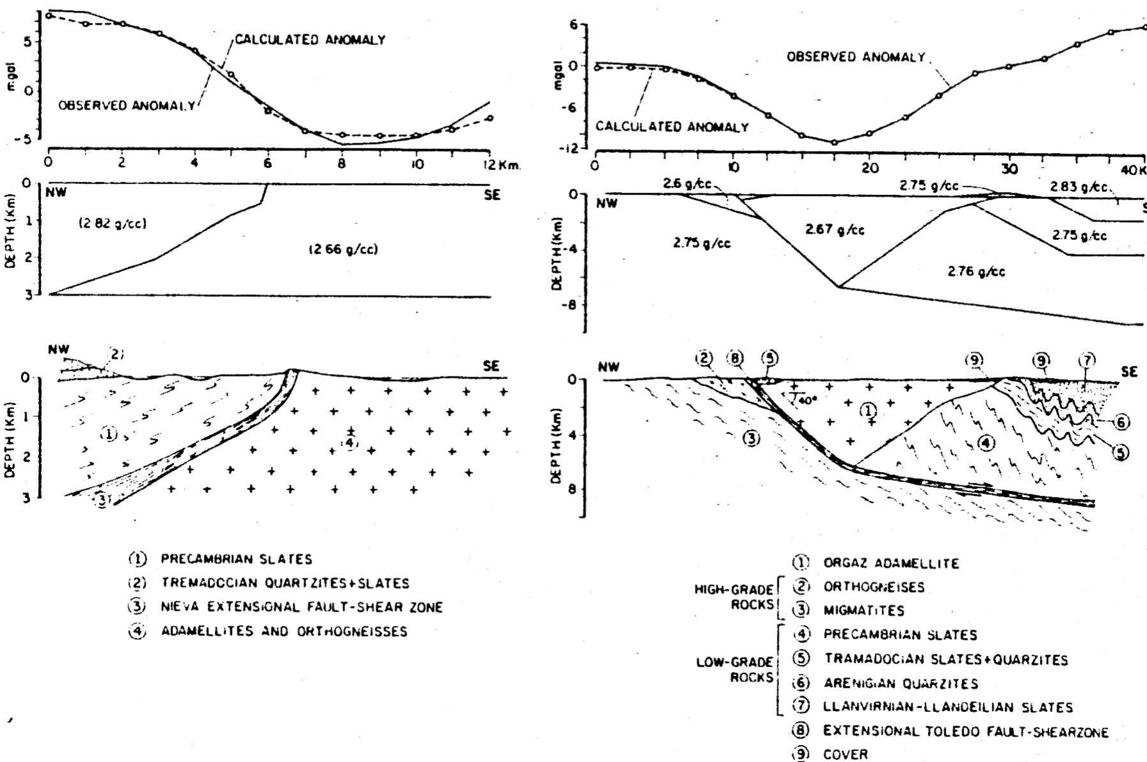

Fig. 2.- Observed and calculated Bouguer anomaly, and corresponding gravimetric and geological models for the Nieva (left) and Toledo (right) Fault-Shear Zones.

A limited number of Rb/Sr whole rock ages of the Spanish Central region granitoids are available (VIALETTE et al.1981;IBARROLA et al., 1987 and ANDONAEGUI & IBARROLA, 1987).

The adamellites give values between 344-320 Ma (three isochrons); coarse grained granites give ages between 310-305 Ma (two isochrons) and leucogranites between 290-287 Ma (three isochrons). Finally, some adamellites with occasional amphibole give an age of 275 Ma (one isochron). Thus the dated magmatism later than the compressive Hercynian phases span a range of at least 70 Ma, i.e. from the Viseean to the Early Permian. Dyke-swarms are still younger.

STRUCTURAL FEATURES OF THE GRANITOIDS

The detailed architecture of the S.C.S plutons is still unknown. However the structural and cartographic data avalaible allow one to make some distintions.

1) The adamellitic units are the most extended. They are often porphyritic, and show a complex structural internal organization, with large areas in which planar flow structures show gentle dips (less than 40°), bounded by zones with subvertical foliations. These are north-south trending bands situated along the contacts with the metamorphic outcrops as at La Caada and El Escorial (Fig.1). They are complex. Many of the formerly mentioned earlier basic to intermediate intrusions are located in or close to these zones. Furthermore a tectonic, i.e..subsolidus foliation, can also be found.

Flow lineation in these plutons, as defined by cozonal arrangements of phenocrysts and long axis of microgranular inclusions are often northerly oriented. MARTIN ESCORZA (1987) in a general study of these inclusions in S.C.S. shows that they are mostly oblate (K<1) with an statistical tendency for the X axis to show a N-S orientation. This has also been demostrated by SANTA TERESA on the basis of phenocrysts, cozonal arrangements of planes (010) of plagioclases and quartz fabric.

These data suggest that the adamellitic units are largely flat-lying sheet-like bodies emplaced in a N-S direction with lateral boudaries controlled by subvertical tectonic accidents with horizontal shear components.

2) Coarse grained granitic units such as La Pedriza and La Cabrera form cupula-like stocks of lateral steep walls. They are structurally more or less isotropic although they show a tendency for an E-W stretching, thus suggesting some extent of structural

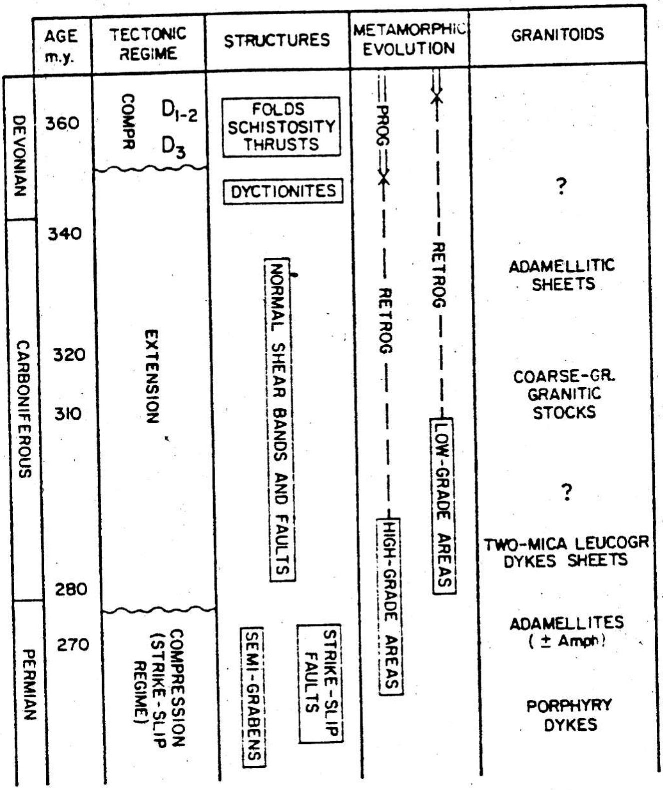

Fig. 3.- Proposed geological evolution for the Hercynian and late-Hercynian times in the eastern Spanish Central System.

extensional hercinico en el S.C.E. Interpretacion Geofisica y Geologica. X Reunion Geologia del Oeste Peninsular, Coimbra. Salamanca

BRANDEBOURGER, E. (1984).
Les granitoides hercyniens tardifs de La Sierra de Guadarrama (Systeme Central Espagne). These Doctorel, Univ. Lorraine, 209 pp.

BRANDEBOURGER, E., CASQUET, C. DEBON, F., FUSTER, J.M., IBARROLA, E., ISNARD, P., LE FORT, P., NAVIDAD, M., PEINADO, M., STUSSI, J.M. Y VILLASECA, C. (1983)
Nota previa sobre la petrologia y geoquimica de los granitoides de la Sierra de Guadarrama (Espana). Studia Geol. Salmant. 18, 251-264.

CAPOTE, R., GONZALEZ CASADO, J.M. Y DE VICENTE, G. (1987)
Analisis poblacional de la fracturacion tardi-hercinica en el Sector Central, del Sistema Central Iberico. Cuad. Lab. Xeol. Laxe 11, 305-311.

CASILLAS, R. y PEINADO, M. (1987).
Secuencias graniticas en el area de San Martin de Valdeiglesias (Sistema Central Espanol). In Geologia de los granitoides y rocas asociados del Macizo Hesperico . Bea et al. (eds.) Ed. Rueda. 281-292.

CASQUET, C. y NAVIDAD, M. (1985).
El metamorfismo en el Sistema Central Espanol. Comparacion entre el sector central y el oriental en base al zonado del granate. Rev. R. Acad. C. Exact. Fis y Nat. 79, 523-548.

DOBLAS, M. (1988).
SC deformed granitoids in the San Vicente Range (Central Spain). Rev. Soc. Geol. Espana 1. 25-35.

DOBLAS, M. (1987).
Tardi-Hercynian extensional and transcurrent tectonics in Central Iberia. Abstracts of Conf. on Deformation and Plate Tectonics. Gijn (Spain) 29.

DOBLAS, M., CAPOTE, R. y CASQUET C. (1983).
Fenomenos de cizalla en los granitoides de la Sierra de San Vicente (Sierra de Gredos). Studia Geol. Salmant. 18, 27-38

FUSTER, J.M. y VILLASECA, C. (1987).
El complejo plutonico hercinico-tardihercinico del Sistema Central Espanol. In Geologia de los granitoides y rocas asociados del Macizo Hesperico. Bea et al. (eds.) Ed.

Rueda. 27-35.

GIBBS, D. (1984).
Structural evolution of extensional basin margins. J. Geol. Soc. Am. 82, 2387-2396.

GONZALEZ CASADO, J.M. (1986).
Estudio geologico de la zona de cizalla de Berzosa-Honrubia (S.C.E.). Doct. Thesis. U. Complutense Madrid. 294 pp.

GONZALEZ CASADO, J.M. Y CASQUET, C. (1988).
Estructuras distensivas y procesos metamorficos asociados en la Zona de Cizalla de Berzosa. Geogaceta 4, 5-6.

GONZALEZ-LODEIRO, F., MARTINEZ-CATALAN, J.R., MACAYA, J. y ALVAREZ, F. (1988).
Sobre la estructura del Antiforme de El Cardoso y el Sinforme de Majaelrayo y su relacion con la Falla de Berzosa. Geogaceta, 4, 11-14.

HERNANDEZ ENRILE, J.L. (1987).
Extensional tectonics of the Toledo ductile shear zone, Central Iberian Plate (Spain). . Abstract of Conference on Deformation and Plate tectonics. (Gijn, Spain). 83-84

HUERTAS, M.J. (1986).
Porfidos y diques basicos asociados en la Sierra de Guadarrama. Cuad. Lab. Xeol. Laxe 10, 245-260.

IBARROLA, E., VILLASECA, C., VIALETTE, Y., FUSTER, J.M., NAVIDAD, M., PEINADO, M. y CASQUET, C. (1987).
Dating of Hercynian granites in the Sierra de Guadarrama (Spanish Central System). In Geologia de los granitoides y Rocas Asociadas del Macizo Hesperico. Bea et al. (eds. Ed. Rueda. 377-383.

MARTIN ESCORZA, C. (1977).
Estudio preliminar de algunos procesos de deformacion y cataclasis en la Zona de Robledo de Chavela (Sistema Central) . Bol. Geol. Min. 88, 471-493.

MARTIN ESCORZA, C. (1981).
Un proceso de milonitizacion con extension cortical en el macizo metamorfico de El Escorial (Cordillera Central). Cuad. Geol. Iber. 7, 577-590.

MARTIN ESCORZA, C. (1987).
Estructurologia de los enclaves microgranulares del Sistema Central. In Geologia de los Granitoides y Rocas Asociadas