Trabajos de Geología, Universidad de Oviedo, 29 : 234-236 (2009)

Variscan recumbent folding of Ordovician plutons in the Malpica-Tui Unit (NW Iberia)

R. Díez Fernández[1*] and J. R. Martínez Catalán[1]

[1]*Departamento de Geología, Universidad de Salamanca, 37008, Salamanca, Spain.*

[*]*e-mail: georuben@usal.es*

Abstract: A structural analysis in orthogneissic massifs of a subducted fragment of the external edge of Gondwana during the onset of the Variscan collision has been carried out, and reveals the generation of recumbent folds and associated axial planar foliation formed during its exhumation. These folds nucleated in irregular igneous bodies, which were initially deformed during the subduction event, show east to southeast vergence. Down-plunge projection of surface data and series of regularly spaced cross-sections have been used to build 3D models of the two main bodies of orthogneiss and to constrain their original igneous shape.

Keywords: Variscan collision, exhumation, Malpica-Tui Unit, recumbent folds.

The Malpica-Tui Unit is one of the basal units of the allochthonous complexes in Galicia (NW Spain). These units consist of a thick pile of terrigenous sediments intruded by basic and acid Ordovician magmas. Acid magmas are represented by calk-alkaline, alkaline and peralkaline orthogneisses, whereas basic magmas crop out mainly as meter-scale boudins intercalated in the metasediments and calk-alkaline felsic bodies, and in many instances represent strongly deformed dikes.

The basal units represent a fragment of the northern Gondwana margin having experienced Early to Middle Ordovician rift-related plutonism, early Variscan subduction and subsequent exhumation during their emplacement over more internal parts of the continent. (Floor, 1966; Arenas *et al.*, 1986; Ribeiro and Floor, 1987; Martínez-Catalán *et al.*, 1996; Pin *et al.*, 1992).

The igneous bodies represent a competence contrast respect to the sedimentary host, what would allow fold nucleation and amplification during each deformation event (subduction, exhumation and late folding). Structural analysis of Early Ordovician orthogneisses in the southern part of the unit has led us to the distinction between two generations of folds affecting previously flattened igneous bodies, as well as relicts of an original igneous morphology typical of extensional geodynamic contexts.

For the alkaline and peralkaline orthogneisses of Serra do Galiñeiro, to the south of the town of Vigo, the contacts show inflexions that can be interpreted as folds hinges in zones where a marked obliquity is observed between the contacts and the main tectonic foliation (Fig. 1). The axes of large folds have been deduced from measured minor folds and from the intersection between the regional foliation and the contact surfaces of the orthogneisses or the sedimentary layering in the surrounding schists (Díez-Fernández *et al.*, 2006).

Several down-plunge sections normal to the fold axis orientation (N35ºE/17ºNE) have been constructed and integrated. The result reveals the existence of a

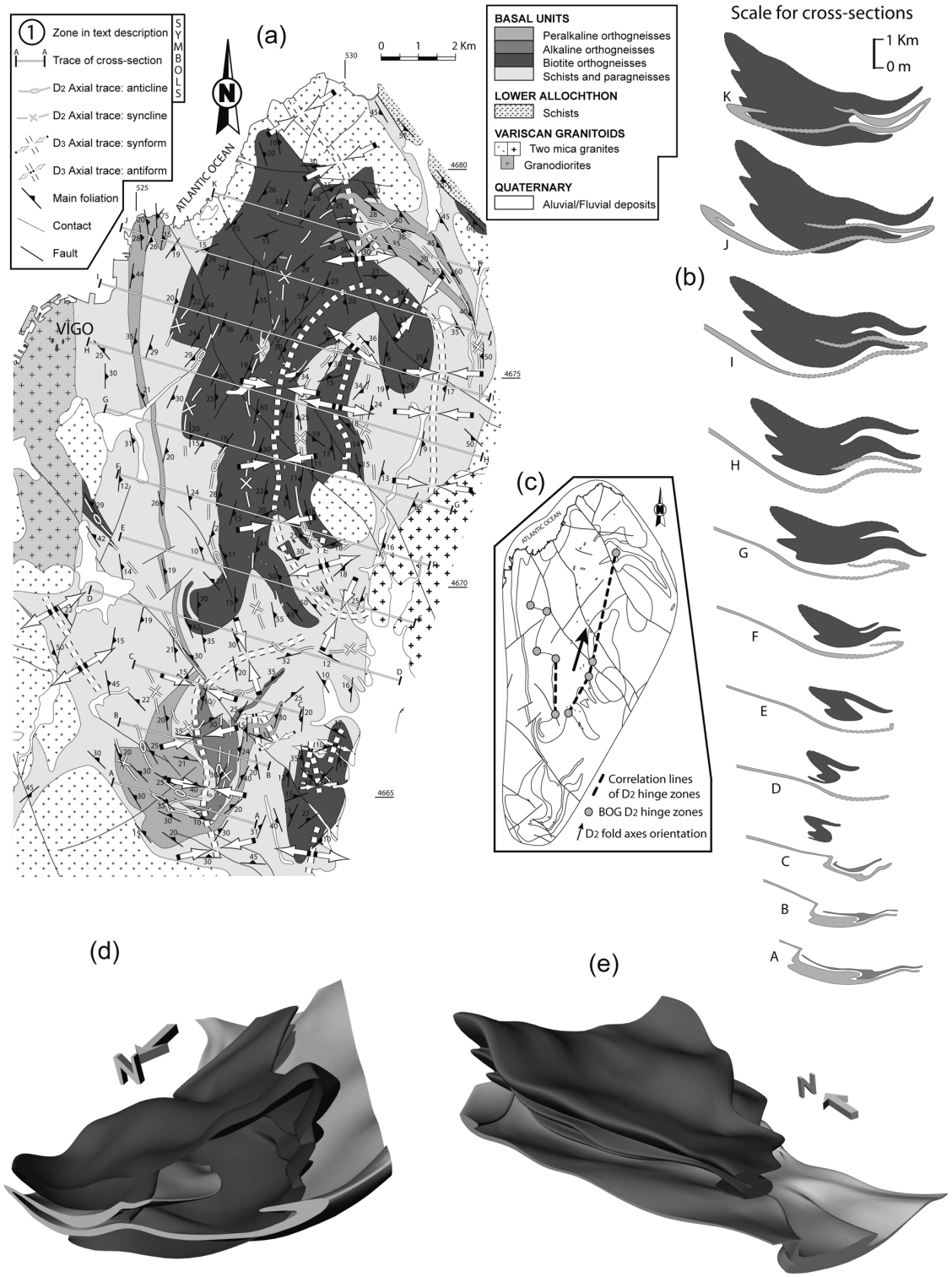

Figure 1. (a) Structural map showing D_2 and D_3 axial traces, (b) serial cross-sections drawn normal to the mean D_2 fold axes, (c) sketch with the correlation of D_2 hinge zones (thick dashed lines) that support a NE to NNE trend for D_2 recumbent folds. Fault displacements have been removed in the cross-sections to obtain the clearest possible view of the ductile structures. Dashed lines in the sections indicate interpretation not constrained by the map, (d) and (e) two 3D perspectives of the main massif of biotite orthogneiss (BOG) made tracing a surface envelope joining the structurally correlated and regularly spaced cross-sections in (b).

train of recumbent folds verging to the SE, with an axial planar foliation refracted in their hinge zones. The recumbent folds were subsequently bent into open folds with vertical axial surfaces.

Analysing the cartographic patterns of biotite orthogneisses of the calc-alkaline group and their relationships with the axial planar foliation of the recumbent folds, hinge zones and limbs can be recognized for the first generation of folds (recumbent), and the interference pattern with the late open folds can be established. A mayor recumbent syncline has been recognized in the biotite orthogneisses, obtaining a cartographic check-up of a NE orientation for the axis of the recumbent folds; the same deduced from recumbent folds in the peralkaline orthogneisses.

Regularly-spaced serial cross sections normal to the axial direction of the recumbent folds have been constructed for the biotite orthogneisses. They depict a tight recumbent syncline, nucleated in an irregular, initially lenticular massif elongated in the N-S direction, which hosts at its hinge zone a semiannular body of peralkaline orthogneisses that draws what seems to be a recumbent anticline in the core of the syncline.

The apparent contradiction can be solved by interpreting the semiannular body as a ring dike, which is in agreement with its peralkaline composition. Arcuate, oval, circular or polygonal shapes in plan view, with near vertical to steeply outward-dipping contacts and variable thicknesses and sizes (could be as much as several kilometres) are the expected shapes in alkaline to peralkaline intrusions related to volcano-plutonic magma plumbing systems in a crustal extensional scenario (Johnson *et al.*, 2002; Cole *et al.*, 2005).

The syncline-hosted semiannular peralkaline body and tiny isolated peralkaline masses that discontinuously complete the ring are consequently interpreted as an incomplete ring dike cutting across an older biotite granitoid and its metasedimentary country rocks. This suggests an emplacement mechanism through near-vertical ring faults generated during collapse and fracturing of the roof above a magma chamber with a subsequent injection of magma (Kresten, 1980; Johnson *et al.*, 2002). The ensemble was subsequently flattened and stretched during continental subduction in early Variscan times, affected by recumbent folds and bent into a late open synform.

Combining the alkaline to peralkaline magmatism and the structural evidence of rift tectonics presented here, our data support a geodynamic extensional context in the basal allochthonous units of NW Iberia during the Early to Middle Ordovician. Extension would have been developed in the continental margin of northern Gondwana and was probably related to the opening of the Rheic Ocean.

References

Arenas, R., Gil-Ibarguchi, J. I., González-Lodeiro, F., Klein, E., Martínez-Catalán, J. R., Ortega-Gironés, E., de Pablo-Maciá, J. G., and Peinado, M. (1986): Tectonostratigraphic units in the complexes with mafic and related rocks of the NW of the Iberian Massif. *Hercynica*, II: 87-110.

Cole, J. W., Milner, D. M. and Spinks, K. D. (2005): Calderas and caldera structures: a review. *Earth Sci. Rev.*, 69: 1-26.

Díez-Fernández, R., Martínez-Catalán, J. R. and Abati-Gómez, J. (2006): Plegamiento recumbente en la Serra do Galiñeiro (Pontevedra, NO España). *Geogaceta*, 40: 3-6.

Floor, P. (1966): Petrology of an aegirine-riebeckite gneiss-bearing part of the Hesperian Massif: the Galiñeiro and sourrounding areas, Vigo, Spain. *Leidse Geologische Mededelingen*, 36, 203 pp.

Johnson, S. E., Schmidt, K. L. and Tate, M. C. (2002): Ring complexes in the Penninsular Ranges Batholith, Mexico and the USA: magma plumbing systems in the middle and upper crust. *Lithos*, 61: 187-208.

Kresten, P. (1980): The Alnö complex: tectonics of dike emplacement. *Lithos*, 13: 153-158.

Martínez-Catalán, J. R., Arenas, R., Díaz-García, F., Rubio-Pascual, F. J., Abati, J. and Marquínez, J. (1996): Variscan exhumation of a subducted Paleozoic continental margin: The basal units of the Ordenes Complex, Galicia, NW Spain. *Tectonics*, 15: 106-121.

Pin, C., Ortega-Cuesta, L. A. and Gil-Ibarguchi, J. I. (1992): Mantle-derived, early Paleozoic A-type metagranitoids from the NW Iberian Massif: Nd isotope and trace-element constraints. *B. Soc. Geol. Fr.*, 163: 483-494.

Ribeiro, M. L. and Floor, P. (1987): Magmatismo peralcalino no Maciço Hespérico: sua distribução e significado geodinámico. In: F. Bea, A. Carnicero, J. C. Gonzalo, M. López-Plaza and M. D. Rodríguez-Alonso (eds): *Geología de los granitoides y rocas asociadas del Macizo Hespérico*, Ed. Rueda, Madrid: 211-221.