

similar de Cu, Ni y Co, la Mina del Aramo (Riosa, Asturias), muestran temperaturas de homogeneización entre 80°C y 170°C, con un máximo de temperaturas medidas entre 120°C y 125°C, lo que concuerda con estos datos.

La abundancia de disulfuros metaestables en el primer episodio está en consonancia con el carácter hipersalino y bituminoso de la roca encajante, capaz de general altas fugacidades de azufre (González-Lastra, 1978). La presencia de marcasita en la mineralización hipogénica indica una acidización del medio.

En conjunto se puede considerar la mineralización como el resultado de

la interacción entre fluidos de carácter ácido y origen profundo, con un medio alcalino y reductor, posibilitando la precipitación cíclica, esencialmente en forma de sulfuros, de un importante stock metálico. La morfología del yacimiento, tanto como el carácter carbonatado de la roca encajante favorecen la penetración posterior y en profundidad, de aguas meteóricas, desarrollando así una importante alteración supergénica.

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Paleobiogeographical aspects of the Ordovician mediterranean faunas

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ABSTRACT

The distribution of the faunas and sediments of mediterranean character is related to paleogeographical aspects (epicratonic seas at high latitudes surrounding the Gondwanan continent) as well as to global transgressive-regressive cycles which, together with some oceanic currents, facilitated the interprovincial dispersal of certain characteristic elements throughout several epochs of the Ordovician Period.

RESUMEN

La distribución de las asociaciones fosilíferas de «tipo mediterráneo» está relacionada con factores paleogeográficos (mares epicratónicos de latitudes elevadas próximos al continente de Gondwana) y con los ciclos globales de transgresión-regresión que, combinados con las corrientes marinas, facilitaron la dispersión interprovincial de algunos elementos característicos a lo largo de diversas etapas del Período Ordovícico.

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According to modern palinspastic reconstructions based on paleomagnetic data, a large part of western and central Europe, eastern Newfoundland-Nova Scotia (Acadia, Avalonia) and the Appalachian Piedmont were assembled during the Ordovician Period as «ibero-armoric» cratonic blocks or microplates (2), closely associated at

high southern latitudes with the southernmost margin of the Gondwanan continent (fig. 1). This area was characterized by the predominance of clastic sediments, often enriched in iron compounds, and by the virtual absence of well developed limestones. The faunas of the whole area are also closely related and are considered as

of the cold-water type, belonging to the *Selenopeltis* province of trilobites, Atlantic province of epiplanktonic graptolites, Anglo-French, Celtic and Bohemian subprovinces of the European brachiopod realm, as well as to the Northatlantic conodont realm (6, 9). The inshore faunal communities of the Mediterranean Ordovician are



Fig. 1.—Early Ordovician (Arenig-Llanvirn) paleogeographic reconstruction of the southern hemisphere (polar projection, modified from different authors). Land areas are denoted by the oblique shading: 1, Laurentia; 2, Baltic-Podolian craton; 3, Kazakhstan; 4, Gondwana. The square shading indicates the possible extent of the polar ice sheet (cf. reference 3). Its limits are taken inside the distribution of the inshore *Neseuretus* biofacies (black points) over Gondwanaland.

typified by the *Neseuretus* biofacies, which were restricted to shallow seas and epicratonic platforms around Gondwanaland at high to relatively high latitudes. On the other hand, the Cyclopygid biofacies includes the most exterior trilobite associations represented by mesopelagic atheloptic forms often occurring in off-shelf environments. The correlation between both belts is always favoured by the common presence of either epiplanktonic or epipelagic elements such as graptolites and trilobites like *Selenopeltis*, or else by the occasional mixture of both communities near the shelf edge environments with trinucleids (4, 5).

In the stable shelf areas and epicratonic blocks which exhibit mediterranean faunistic and lithological features, uniform sedimentary conditions developed by the time the global transgressions took place, introducing the same kind of shallow clastics over wide and large areas. This is exempli-

fied by the ubiquitous *Cruziana*-sandstone facies, represented in the lower Ordovician of Ibero-Armorica, the Welsh Borderland, eastern Newfoundland, central Moroccan Anti-Atlas, Algerian Sahara, Tunisia, south-east Turkey, Jordan, Iran, Irak, Saudi Arabia, central Afghanistan and north-western Argentina, Bolivia and Peru. This suggests the position of the marginal areas around Gondwanaland, though some of them are located at slightly lower paleolatitudes. After the deposition of the Armorican quartzite over a large part of the mediterranean area, the subsequent widespread Llanvirn transgression produced in these areas a flood of dark shales with pendent didymograptids and benthic elements of the *Neseuretus* biofacies (3). A large part of these latter elements had been previously recorded in the Arenig of the British Isles (*Ectillaenus*, *Neseuretus*, *Merlinia*, *Placoparia*, *Ogyginus*, *Ortham-*

bonites, *Monorthis*, *Praenucula*, *Glyptarca*), the Montagne Noire in southern France (*Neseuretus*, *Merlinia*, *Colpocoryphe*, *Pradoella*, *Bathychelilus*, *Pterygometopus*, *Hungioides*, *Babinka*, *Coxiconcha*, *Redonia*, *Ribeiria*, *Tolmachovia*, *Orthambonites*), and the Moroccan Anti-Atlas (*Bathychelilus*, *Colpocoryphe*, *Pterygometopus*, *Prionocheiulus*, *Neseuretus*), including throughout the Llanvirn and Llandeilo times a great number of new endemic elements, but some others showing subsequently a broad interprovincial dispersal as happened with the trilobite genera *Nobiliasaphus*, *Placoparia* (*Coplocoparia*), *Crozonaspis* and *Eccoptochile*. The absence of *Neseuretus* in some mediterranean areas, where the Armorican quartzite was also not deposited, may be explained in terms of non-appropriated bioenvironments, perhaps with highly pronounced shelves, where the Cyclopygid biofacies are preponderant. This is characteristic of areas such as Bohemia, Germany, Bulgaria, etc., but also of external sites of the ibero-armorican platforms, as the Ancenis syncline (southern Armorican Massif), the southern Ossa Morena zone, and scattered localities of north Africa. Subsequently, after the times of short-regressions events that took place during the Llandeilo, some of these deep-water forms migrated to more inshore habitats through the open shelf areas, thus favouring the faunistic exchanges between Ibero-Armorica and Bohemia/Morocco as is shown by the appearance of the genera *Prionocheiulus*, *Zeliskella*, *Nobiliasaphus*, *Archinacella* and *Calix* in the lowermost Llandeilo, and *Eoharpes*, *Dionide*, *Parabarrandia* and *Placoparia* higher, in the Hupei Zone.

The faunal migrations along the inner edge of the platforms were favoured by specific patterns of oceanic currents. One of these may explain the arrival of South-American brachiopods, like *Aegiromena*, *Tissintia* and *Eorhipidomella*, to Europe and north Africa during several Arenig, Llanvirn and lower Llandeilo episodes (7), whereas a clockwise inverse gyre (8) provided the presence of elements of the *Selenopeltis* fauna in Florida, Peru, Bolivia and north-western Argentina. Graptolite associations of both pacific and atlantic affinities may be found in these extreme places. The dispersal of benthic ele-

ments was slower, and progressed in either one or the other sense through successive epochs; for instance, species occurring in the south american Arenig reached Europe in the Llanvirn and Llandeilo, and vice versa.

A third important current which can be recognized in the mediterranean Ordovician may explain the baltic influences evidenced in Ibero-Armorica and the Sobova Formation of Turkey during the Llanvirn and Llandeilo transgressive/regressive cycles. This migration is characterized by the arrival of epipelagic faunas like *Gymnograptus linnarsoni*, *Glyptograptus cernuus* and *Gl. vikarbyensis*, and the ostracod genus *Quadrilia* (*Krutitia*) in the Llandeilo time, unknown in the British Isles, but there were also benthic elements which crossed the mide european Ocean during the Llandeilo regression taking advantage of emerged or shallowed zones; for example, the trilobite genus *Panderia*, as well as the ostracod genera *Vogdesella*, *Klimphores* and *Laterophores* (10).

Nevertheless, the best-developed pattern of oceanic current is the one that on a west-east orientation ran along

the oriental edge of the Gondwanan continent, starting from the British Isles or Ibero-Armorica, where it had a first north-south component, as in the Armorican Massif. Such currents allowed certain Arenig brachiopods and trilobites of the *Selenopeltis* province, such as *Taihungshania*, *Hanchungolithus*, *Hungioides*, *Neseuretus*, plimerids and *Sinorthis*, to reach the south of China in the Llanvirn time via Turkey, Saudi Arabia (where *Ningianolithus* is added), and Iran and Afghanistan. Some of them, as *Neseuretus* and *Hungioides*, extended into central Himalaya and western Australia at the same epoch, and reached areas of northern Siberia during the Llandeilo (*Neseuretus*, *Nobiliasaphus* and some Marrolothinae). The epiplanktonic graptolite faunas of these australasian areas also show a mixture of «atlantic» and «pacific» elements.

Additionally, the suggested course of these oceanic currents may explain the subsequent interprovincial faunal dispersal of some platform conodonts of south american, baltic or ibero-armoric origin, as for instance *Amorphognathus*, *Eoplacognathus* and *Pygodus* (1).

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Discordancia intra-Alcudiense en el anticlinal de Agudo (Ciudad Real-Badajoz)

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ABSTRACT

The Proterozoic unconformity, also known more to the East, is described in the Agudo Anticline at the base of the Upper Alcudian (Upper Vendian) and extended to the whole anticlinory. This allows the extension of the Intra-Alcudian unconformity to the W.

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Introducción

El anticlinal de Agudo constituye la rama más septentrional del anticlinorio de Agudo-Valdemanco, estructura caledono-hercínica orientada casi O-E, en cuyo núcleo afloran materiales proterozoicos «alcudienses» bajo co-

bertera fundamentalmente ordovícica, y que encuadra en la «Subzona Luzo-oriental-Alcúdice» de Lotze (1961), de la Zona Centro-Ibérica (fig. 1). Está flanqueado al N y SE por los sinclinales paleozoicos de Herrera del Duque y Almadén respectivamente. Se abre hacia el O dando paso sin

solución de continuidad al gran «Anticlinorio Centro-Extremeño», con distintas directrices tectónicas. En el sector oriental está dividido el anticlinorio, de N a S, en Anticlinical de Agudo, Sinclinal ordovícico de Riófrío y Anticlinical de Valdemanco (fig. 2).