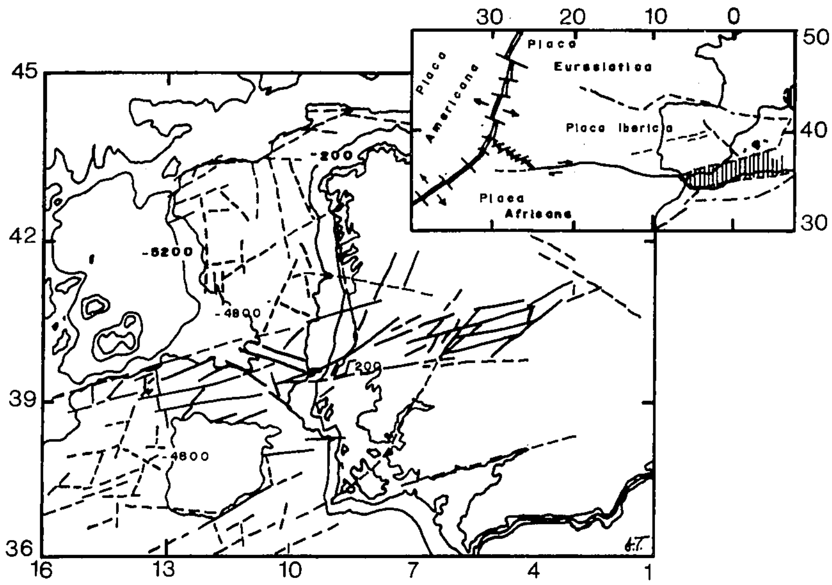

Fig. 1.—Extensión de la zona de cizalla intraplaca del centro de Iberia, en trazos continuos. El encuadrado muestra su posición respecto a los bordes de placa.

Teniendo en cuenta la anchura de la zona considerada, estos valores son coherentes con una deformación de relativa intensidad sin ser necesarios grandes desplazamientos en la horizontal. Por otra parte, tampoco es necesario recurrir a un acortamiento o extensión considerables de la corteza para la formación del relieve.

Edad de la deformación y contexto geodinámico

La situación tectónica de los relieves submarinos de Tore, la edad de los sedimentos de las cuencas interiores y la deformación de los sedimentos en los bordes de la cadena permiten fijar el inicio de la deformación en el Cretácico Superior, continuando la actividad hasta el Mioceno Medio. A partir de esta época los movimientos deben corresponder a reajustes isostáticos. Desde un punto de vista morfogenético, la deformación por cizalla se produce durante la fase *prearcósica,* hasta parte de la fase *arcósica* del esquema propuesto por Pedraza (1981) para el Sistema Central. Sin embargo, no podemos precisar si el comienzo de la rotación horizontal de los bloques —es decir, la intensificación del relieve— se realiza sin solución de continuidad, o bien corresponde a una fase tectónica diferente correspondiente a la evolución *postalpina* de Iberia (Vegas y Banda, 1982).

En cuanto al significado geodinámico, es evidente que esta zona de cizalla absorbió parte del movimiento entre Eurasia y Africa al idependizarse Iberia como unidad tectónica intermedia. No obstante, esta zona no evolucionó hasta formar una frontera de placas de segundo orden (ver encuadrado de la fig.) en el conjunto de la evolución geodinámica del área Ibero-Mogrebí (Vegas, 1985).

Conclusiones

La formación del relieve del Sistema Central puede relacionarse con la actividad de una zona de cizalla intracontinental comprendida en la tectónica intraplaca de Iberia desde el Cretácico Superior al Mioceno Medio.

En esta zona de cizalla se produce rotación de bloques y deformación interna distribuida. Este tipo de deformación y su evaluación permiten explicar las características morfoestructurales del Sistema Central como cadena de bloques. Los datos de sísmica profunda (Suriñach y Vegas, en preparación) apuntan hacia la confirmación de este modelo.

Referencias

Lallemand, S.; Mazé, J. P.; Monti, S., y Sibuet, J. C. (1985): *C. r. Acad. Sc. París, 300,* II, 4; 145-149.

Luyendik, B. P.; Kamerling, M. J.; Terres, R. R., y Hornafius, J. S. (1985): *J. Geophys. Res., 90, B-14;* 12454-12466.

Pedraza, J. de (1981): *Cuad. Geol. Ibérica, 7;* 667-682.

Ron, M.; Freund, R.; Garfunkel, Z., y Nur, A. (1984): *J. Geophy. Res., 89, B7,* 6256-6270.

Vegas, R. (1985): En: *Mecanismo de los terremotos y tectónica.* Pub. de la Univ. Complutense.

Vegas, R. y Banda, E. (1982): *Earth Evol. Sc., 4;* 320-343.

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Depositional sedimentary controls on sepiolite occurrence in Paracuellos de Jarama, Madrid basin

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RESUMEN

La presencia de sepiolita en los sedimentos neógenos (Aragoniense medio y superior) aparece ligada a paleoambientes de orla distal en abanicos aluviales. Dentro de ellos la

formación de sepiolita tuvo lugar en charcas de carácter más o menos perenne próximas al borde de un lago salino, así como a cuerpos de agua desarrollados en la orla en momentos de retrogradación o estabilización relativa de los abanicos. Un último ambiente de formación de sepiolita son los perfiles de calcreta que aparecen ampliamente desarrollados en estas zonas distales del sistema aluvial.

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Key words: *Sepiolite, alluvial fan, Neogene, Madrid basin.*

Introduction

Sepiolite is known to be originated in several different sedimentary environments: marine, hydrothermal, lacustrine and soil profiles (see Singer & Galan, 1984, for a review). Sepiolite occurrences in the continental realm are usually restricted to saline lakes (shallow, pluvial, playa-lakes) and arid-zone soils. According Millot (1970) sepiolite would constitute an end-member product of the geochemical sequence in clay deposits of confined (closed) basins. Sepiolite deposits in the Madrid Basin (central Spain) were interpreted during the last decade on the basis of the Millot's model. However, recent advances on lithostratigraphy and sedimentology of the Neogene in this basin have demostrated that economic sepiolite deposits are located in rather marginal palegeographic positions and they are related with alluvial fan systems in the northern and northwestern areas of the basin (Megias *et al.,* 1982; Leguey *et al.,* 1984; Galan & Castillo, 1984).

Recently, a detailed study on neogene sediments cropping out in the Paracuellos de Jarama area, near Madrid (fig. 1), has been carried out by Alonso *et al.,* 1986). They showed that the architecture of the Neogene record in this area is mainly controlled by the transition between arkosic alluvium systems coming from the North and paludal environments furtherly developed towards the centre of the basin. They also attained to describe that sepiolite occurrences are intimately related to the most distal areas of the fan fringes.

In this paper we analize the sepiolite deposits in Paracuellos de Jarama. Emphasis is done on sedimentary facies associated to the sepiolite, although mineralogical and petrographic characteristics of the clay deposits themselves are briefly described too.

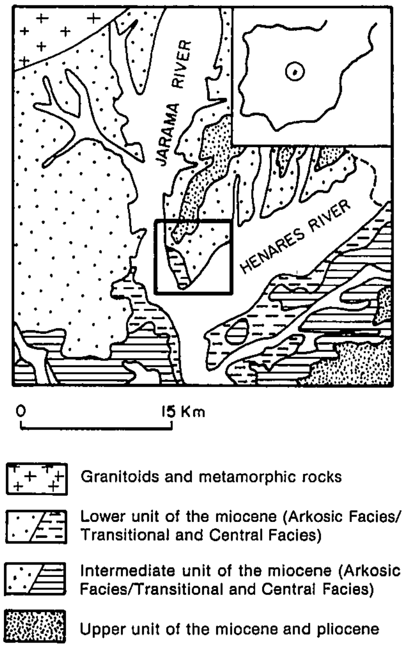

Fig. 1.—Geographic and geologic setting.

Techniques

Bulk of the analyzed material was collected in a previous work (Alonso *et al.,* 1986, o.c.). Further samples were later taken in selected sepiolite occurrences. Powdered whole-rock samples were X-rayed using Kα radiation and a PW-1410 Philips difractometer. Oriented clay aggregates, $<64\mu$ and $<2\mu$ fractions from these samples were subsequently X-rayed under the same conditions. The same operation was realized on heated (350-550° C) and ethylen-glycol treated clay aggregates of those fractions. Furtherly, samples were studied by Differential Thermal Analysis.

Sepiolite occurrences and facies interpretation

Sepiolite has been recognized in three different lithostratigraphic positions in the Paracuellos de Jarama section, all of them within the Lower Unit defined by Alonso *et al.,* (1986). Moreover, a small outcrop of sepiolite has been detected within the Upper Unit of these authors but sepiolite in that unit is not actually significant. The above mentioned sepiolite occurrences are: 1) massive, well segregated sepiolite deposits associated to green clays, chert and carbonates in the transition zone between the most distal parts of the arkosic alluviums and the paludal, green clay dominated, environment; 2) sepiolite beds alternating with carbonates in a more or less laterally continuous level at the top of the Lower Unit. This level clearly marks a pronounced «retraction» episode in the alluvial fan system; 3) finally, sepiolite is found in calcrete profiles that characterize distal facies of the arkosic alluvial fans, which are constituted by a pile up of fine arkoses-brownish clay-carbonate sequences.

Figure 2 shows X-ray diffraction traces from some sellected sepiolite occurrences corresponding to the mentioned lithostratigraphic positions. Symbols Be, Fp y Cg respectively correspond to (1), (2), and (3) situations. Figure 3 shows D.T.A. traces from similar material. Massive sepiolite in the transition zone typically occurs as nearly pure sepiolite beds overlying green clays consisting of trioctahedral smectites. Sepiolite in this position is commonly capped by carbonates, sometimes affected by silicification processes. A similar mineralogy is displayed by sepiolite occurring at the top of the Lower Unit, although herein sepiolite and carbonate beds are intercalated between lutites in which dioctahedral smectites are predominant. Sepiolite in calcretes may be detected through up the calcrete profiles, which tipycally show a progressive increase in the chain phyllosilicate content from bottom to top. Sepiolite occurs in variable

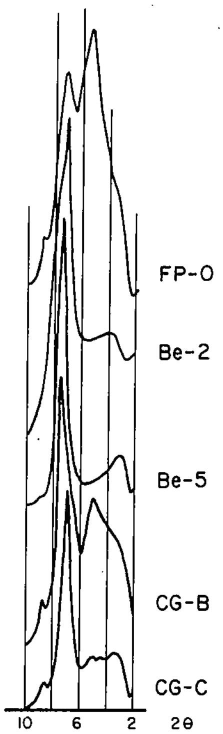

Fig. 2.—XDR traces from some samples.

amounts together with dioctahedral smectites, illites and carbonate minerals. Sepiolite recognition is easier in dense carbonate levels of the calcrete where it occurs on surface peds and filling chanels.

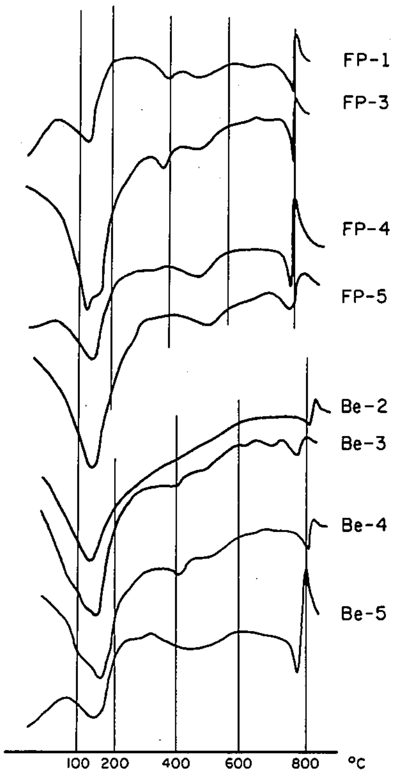

Fig. 3.—DTA traces from some samples.

Carbonate which with sepiolite is associated in calcrete profiles and other occurrences is mainly calcite (LMC). Albeit, dolomite has been found as a significant component within some calcretes, particularly those developed nearest the paludal deposits. By the other hand, chert occurrence in Paracuellos is mainly opal (intimately mixed with sepiolite and replacing carbonates), quartz occurs only as a minor cementing phase.

The sedimentological model drawn in Figure 4 shows the interpreted paleogeographic location of sepiolite deposits in the Paracuellos de Jarama area during the Neogene (middle to upper Aragonian). This is in agreement with, and complements, the most general scheme presented by Galan & Castillo (1984, p. 113).

Massive accumulation of sepiolite took place in shallow, fairly perennial, ponds on low relief zones of the fan fringe (sequence A) that were intermitently flooded by fresh surficial flows as well as by long-standing discharge of ground water flows through the arkosic alluvium (Doval *et al.,* 1986). These ponds, placed in the vicinity of the slightly alkaline lake waters (paludal facies), might be affected by more saline, Mg richer solutions, probably through pumping evaporation mechanisms, as suggested by Megias *et al.,* (1982). So, formation of sepiolite in these ponds is thought to be produced by direct precipitation of the chain clay through addition of magnesium to colloidal silica (Jones, 1985). In addition to this postulate, sepiolite precipitation took place in relatively more dilute waters than needed to form other silicates (Khoury *et al.,* 1982; Jones, o.c.). A similar process is invoked to explain sepiolite occurences at the top of the Lower Unit (sequence B). Herein sepiolite was formed in ponds, too. Intensive precipitation of low-Mg calcite caused the selective removal of calcium, thus favoring an additional way for magnesium enrichment in the pond waters. The occurrence of sepiolite in calcrete profiles (sequence C) has been mainly detected where calcretes spread out on flats of the alluvial fringe, thus suggesting some correlation between chain clay formation and maturity of the calcrete profile (Watts, 1980). Common occurrence of palygorskite in calcretes (Singer, 1984) has not been clearly recognized in the Paracuellos area. Sepiolite was formed as an authigenic mineral in the calcretes through precipitation from vadose solutions. Differences in the mineralogy of the authigenic phases (relative amounts of sepiolite, mixed layer clays or, even, analcime) can be observed from distintc calcrete profiles in Paracuellos. It could be due to slight variations in terrigenous influx (flooding) and eva-

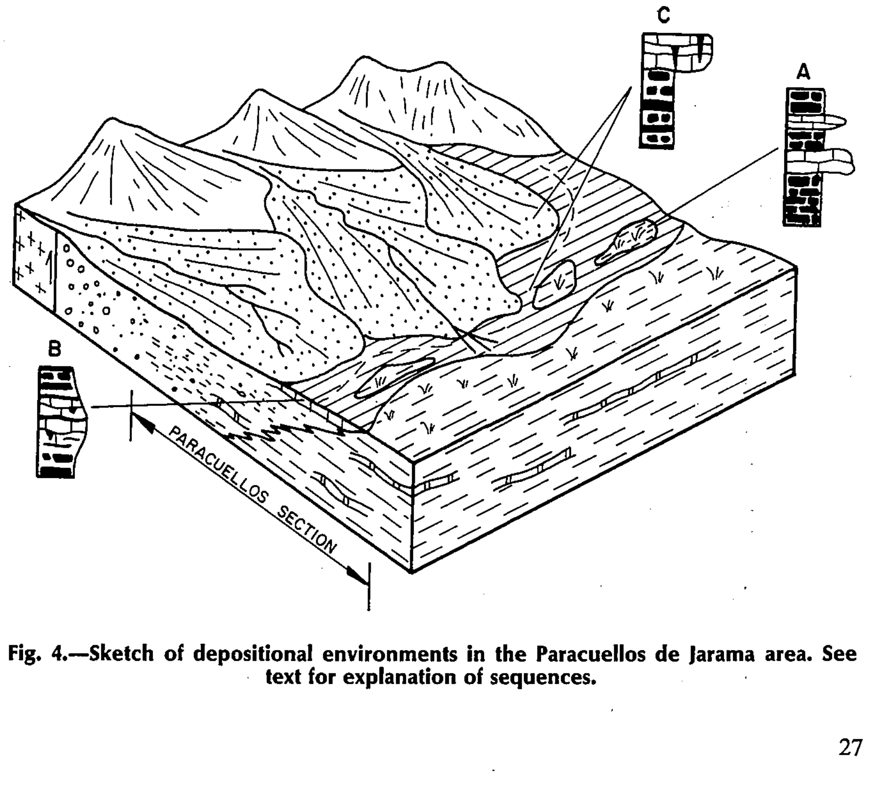

Fig. 4.—Sketch of depositional environments in the Paracuellos de Jarama area. See text for explanation of sequences.

poration rates favoring changes in Ph conditions.

Conclusions

Sepiolite occurrences in Paracuellos de Jarama are restricted to the most distal areas of an arkosic alluvial fan system. Sedimentary subenvironments, i. e. ponds with more or less hydrologic influence of the neighbouring slightly alkaline lake waters, where sepiolite was precipitated evolved according on progressive progradation or retrogradation stages of the alluviums. Sepiolite of pedogenic origin is also found in widely developed calcrete profiles that characterize the distal areas of the fans.

A close relationship between sepiolite ocurrences and sedimentary facies indicative of fresh-water flooding may be concluded from the analysis of the Paracuellos section. So, sepiolite formation seems to take place in relatively dilute waters.

Massive sepiolite deposits at the lower side of Paracuellos area can be compared with those economically extracted in Madrid. The model proposed in this paper is envisaged as a reallistic model for the genesis of the sepiolite in this latter location.

References

Alonso, A. M.; Calvo, J. P. & García del Cura, M. A. (1986): *Estudio Geol.,* 42: 79-101.

Doval, M.; Calvo, J. P.; Brell, J. M. & Jones, B. F. (1986): *Abtracts Symp. Geochem. Earth Surf. and Processes of Mineral Formation. Granada.*

Galán, E. & Castillo, A. (1984): In: *Polygorskite-sepiolite occurrences, genesis and uses,* Elsevier, 87-124.

Jones, B. F. (1985): *U. S. Geological Survey Bulletin* (in press).

Khoury, H. N.; Eberl, D. D. & Jones, B. F. (1982): *Clays and Clay minerals,* 30: 327-336.

Leguey, S.; Ordoñez, S.; García del Cura, M. A. & Medina, J. A. (1984): *I Congreso Español de Geología,* 2: 355-371.

Megías, A. G.; Ordóñez, S. & Calvo, J. P. (1982): *V Congreso Latinoamericano de Geología,* Argentina, 2: 427-439.

Millot, G. (1970): *Geology of clays,* Ed. Springer-Verlag.

Singer, A. (1984): In: *Palygorskite-sepiolite occurrences, genesis and uses,* Elsevier, 169-176.

Singer, A. & Galán, E. (1984): *Palygorskite-sepiolite occurrences, genesis and uses. Elsevier.*

Watts, N. L. (1980): *Sedimentology,* 27: 661-678.

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Comentarios

Federico Ortí.—En relación con el carácter de lago hipersalino, que parece estar en conexión con la génesis de estas sepiolitas, ¿habéis encontrado algunos otros minerales, como quizá carbonatos de Na o K, que completen estas supuestas paragénesis alcalinas?

José Pedro Calvo.—Es posible que la utilización directa del término «alcalino» en lo que se refiere al ámbito lacustre adyacente a los depósitos de sepiolita, conduce a una interpretación equívoca de lo que queremos expresar en cuanto a las características hidroquímicas de dicho ámbito. Al utilizar aquel término nos referimos exclusivamente al pH moderadamente alcalino de las aguas en el sistema lacustre. De acuerdo con esto no habría presencia de fases minerales netamente alcalinas como las señaladas en la pregunta. Recogemos en cualquier caso la observación para introducir en el texto de la comunicación las modificaciones adecuadas.

Petrogénesis de los basaltos alcalinos de La Garrotxa, región volcánica del NE de España

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ABSTRACT

Compositional trends and trace elements abundance in leucite-basanites, nepheline-basanites and olivine basalts from La Garrotxa (NE Spain region), suggest that the parental magma were originated from an homogeneous lherzolite source, strongly enriched in incompatible elements (between x15-x4 the chondritic values for the highly incompatible elements and between x5-x2 for the moderately incompatible), in which neither kaersutite, phlogopite or apatite remained as residual phases. The leucite-basanite magmas were derived by lower degrees of melting (7-10%) than the basanite s.s. and the olivine basalt magmas (13-15%). Except some primary leucite-basanites, the lavas from La Garrotxa underwent a moderate fractionation ($\simeq$20%) of ol + cpx + mg, in proportion that range between 75-40%, 55-10% and 15-0%, respectively.

López Ruiz, J.; Rodríguez Badiola, E., y Cebriá Gómez, J. M. (1986): Petrogénesis de los basaltos alcalinos de La Garrotxa, región volcánica del NE de España. *Geogaceta,* 1, 28-31.

Key words: *Leucite-basanites, nepheline-basanites, olivine basalts, partial melting, fractional crystallization, Upper Mantle, Mediterranean volcanism.*