The Behaviour of the Upper Mantle Sulfide Component During the Incipient Alteration of “Alpine”-Type Peridotites as Illustrated by the Beni Bousera (Northern Morocco) and Ronda (Southern Spain) Ultramafic Bodies

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With 9 Figures
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Summary
A volumetrically minor Cu-Fe-Ni-S component derived from the uppermost mantle is found within the Beni Bousera (northern Morocco) and Ronda (southern Spain) “Alpine”-type peridotites; it occurs today as inclusions within primary silicates or as assemblages disseminated in the intergranular sites of the host rocks. Detailed microtextural and microprobe data indicate that inclusions and intergranular assemblages behaved as two contrasting systems during the low temperature, incipient serpentinization of the host rocks. The former were equilibrated in closed systems whereas the latter behaved as open systems with respect to hydrothermal fluids; as a result, intergranular assemblages were controlled by redox conditions generated by serpentinization. An early stage of alteration is characterized by a slight decrease of the sulfur content and would be due to the first influx of water inside peridotites; a further transformation was produced by anomalous highly reducing conditions responsible for the crystallization of native iron-bearing alloy assemblages as well as for a preferential partitioning of Fe from silicate into pentlandite. The production of anomalous, reducing conditions during incipient serpentinization is ascribed to a low permeability of the host rocks with respect to the diffusion of hydrogen out of the sites of serpentinization. Because of its low temperature behaviour, the intergranular sulfide component would not be of use reconstructing the initial composition of the upper mantle sulfide component; thus, it is concluded that only the sulfide inclusions would provide such informations.

Résumé
Le comportement du composant sulfure du manteau supérieur pendant les premiers stades de serpentinisation des péridotites de type “alpin”; une discussion a partir de l'exemple des massifs ultramafiques de Beni Bousera (Maroc) et de Ronda (Espagne)

Des traces d'un composant sulfure du système Cu-Fe-Ni-S d'origine mantellique sont présentes dans les péridotites "alpines" de Beni Bousera (Maroc) et Ronda (Espagne); il forme actuellement des inclusions dans les silicates primaires ou des plages intergranulaires disséminées dans
les interstices des roches. Une analyse minéralogique et chimique détaillée démontre qu’inclusions et plages intergranulaires sulfurées ont eu un comportement opposé dès les premiers stades de serpentinisation des roches encaissantes. Les premières ont été rééquilibrées en système chimique ouvert vis-à-vis des fluides de serpentinisation; en conséquence les paragenèses intergranulaires résultent d’une suite de transformations du composant sulfuré mantellique, contrôlée par le degré d’oxydo-réduction du fluide de serpentinisation. Dans un premier stade, l’entrée de l’eau dans les péridotites a provoqué une légère baisse de la fugacité du soufre et la cristallisation d’assemblages sulfurés riches en mackinawite. L’augmentation du degré de serpentinisation a ensuite engendré des conditions inhabituellement réductrices responsables d’un important fractionnement du fer libéré par la serpentinisation de l’olivine dans la pentlandite ainsi que de la cristallisation d’une paragenèse complexe de phases métalliques incluant localement le fer natif; ces conditions anormalement réductrices sont imputées à une faible perméabilité des roches encaissantes vis-à-vis de la diffusion de l’hydrogène en dehors des sites de serpentinisation. En raison de leur comportement à basse température, les plages sulfurées intergranulaires sont inutilisables pour reconstituer le composant sulfuré du manteau supérieur; sur ce plan, on conclut que seules les inclusions blindées dans les silicates peuvent apporter des informations.

Pentlandite and other (Cu)-Fe-Ni-S minerals have been found to occur as intergranular assemblages among the primary silicates and spinel within “alpine”-type peridotites (Besson, 1975; Lorand, 1983a and b; Garuti et al., 1984). Some authors assume that this kind of sulfide occurrence represents the product of an almost isochemical subsolidus reequilibration of the upper mantle sulfide component (Garuti et al., 1984). However, a preliminary investigation on more than 300 samples of alpine-type peridotites from various localities has shown that intergranular sulfide assemblages may have suffered low temperature exchange reactions as soon as the degree of serpentinization is greater than 5–10% by volume of the host rocks (Lorand, 1983a and b). The present paper documents these reactions on the basis of a detailed study of the sulfide component in the Beni Bousera (northern Morocco) and Ronda (southern Spain) alpine-type peridotites. Owing to their moderate but highly variable degree of serpentinization, such occurrences of peridotites provide the opportunity to examine the behavior of the sulfide component during the incipient alteration of primary silicates into serpentine minerals.

For each sample, the microscopic and microprobe investigations were performed not only on the intergranular Cu-Fe-Ni-S assemblages but on the sulfides fully enclosed within primary silicates as well; furthermore, the compositional variation of pentlandite has received special attention. A general appraisal of sulfide alterations connected with incipient serpentinization has been attempted with references to the models of Chamberlain et al. (1965) and Eckstrand (1975). Relationships between the present sulfide assemblages from “alpine” type peridotites and the upper mantle sulfide component are also discussed.

I. Geological Setting and Main Petrographic Characteristics

The Beni Bousera (northern Morocco) and Ronda (southern Spain) ultramafic bodies, respectively 70 and 300 km² across, occur as two tectonic lenses within