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[6]

Some fundamental considerations in the dating of glauconies: a comment on "A test of the reliability of Rb-Sr dates for selected glauconite morphologies of the Upper Cretaceous (Navesink Formation) of New Jersey", by R.L. Montag and D.E. Seidemann

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In an attempt to understand the geochemical behaviour of Rb and Sr in *glauconies* (see below) used for dating purpose, Montag and Seidemann [1] stated several hypotheses in contradiction with some facts generally known to the specialists in these difficult problems.

In their introduction these authors define the word glauconite as a mineral but unfortunately also use it to describe the green sedimentary pellets in which glauconitic minerals occur. The term has unfortunately come to be used loosely to cover two concepts: on the one hand a concept of facies: something green, usually in pelletal form, lying in a marine sediment; on the other hand a mineralogic concept which designates a mica [2]. The two concepts cover diverse possibilities. This duality of significance leads us, amongst others [3], to propose to solve this confusion by using: *glaucony* or pelletal glauconite... for the facies and *glauconitic minerals* for the authigenic components of the green pellets [4]. These glauconies may be more or less evolved and fundamentally contain two kinds of components: (1) the inherited ones, which originate from the initial substrate of glauconitization (quartz, mica, clay, calcareous debris) [5]; there is no glauconitization without this preliminary substrate; (2) the authigenic ones, which are the glauconitic minerals, ranging from a smectitic end-member component to a micaceous end-member. Only the latter should actually be named glauconite, (the suffix "-ite" characterizes a mineral). This is a convention, other conventions are possible and we do not intend to impose a solution; but it is certain that the confusion of the two concepts and, within each concept, the non-recognition of their diversity, can only lead to complete confusion in the application to geochronology.

Ages of glauconies are *not* generally 10–20% younger than the age of sedimentation; this old assumption was based on the study of deeply buried samples from North America (which had been rejuvenated) or on a biased time scale [6]. Numerous recent studies have shown that the main problems with the dating of glauconies are, in chronological order: (1) the zero-time problem (see Tisserant and Odin [7] and Fig. 1); (2) possible influences from tectonic and deep burial [8], and (3) possible changes due to weathering [9]. Whatever the colour or the form, the green pellets may lack reliability, for geochronology, due to the three main causes listed above. If the light-green pellets give apparent ages which are often different from the age of sedimentation, it is well recognized today that this is not related to their colour but to the fact that either they are little-evolved or that

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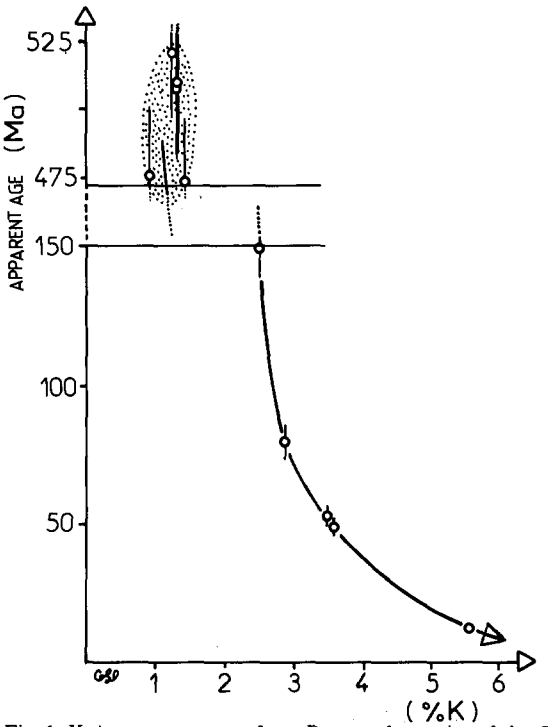

Fig. 1. K-Ar apparent ages from Recent glauconies of the Gulf of Guinea (after Odin [6] and Tisserant and Odin [7]). The dotted area shows the apparent age of the mud eaten by the worms. The coprolites of the worms quickly (10,000 years) become glauconitized: they become green. Authigenic glauconitic minerals appear on the diffractograms. The more evolved are the pellets, the more rich they are in potassium, the more closed are the glauconitic minerals. The zero age is not yet obtained for the more evolved pellets (probably some 100,000 years old). Numerous similar observations exist for glauconies of the stratigraphic column: it is concluded that only the most evolved grains (more than 7% K_2O) are reliable chronometers [5].

they are altered; in both cases, the result may be an apparent age older or younger than the time of deposition and this is also true for some dark-green pellets.

The X-ray diffractograms showing broad (001) peaks for glauconitic grains are *not* related to a "degraded illite" (terms in quotation marks are those used by Montag and Seidemann [1]. *Most frequently*, they indicate an incomplete evolution of the green pellets leading to incompletely closed *authigenic* minerals [3]. Alteration or degradation is not in question here.

The "interlayering of equal amounts of glauconite and kaolinite" is geochemically improbable: sedimentary kaolinite is usually formed on the earth in an acid, weathered environment; glauconite is a marine mineral formed in a basic, little weathered environment [3].

The low Rb content for light-green pellets is *not* a criterion for Rb loss for the following three reasons.

(a) Light-green pellets are often (not always) less evolved than the darker ones; less evolved pellets contain less evolved authigenic glauconitic minerals, and, thus, contain less potassium than more evolved ones [3,10]. The Rb content is proportional to the K content as these two ions, of similar geochemical behaviour, occupy the same crystallographic site.

(b) A loss of Rb from glauconitic minerals without loss of Sr is an unknown phenomenon in natural conditions. Clays as well as micas lose Sr more easily than Rb [11,12]. The result of a weathering can therefore only lead to a diminished apparent age [13,14].

(c) Even if we disregard point (b), a correct age for samples 5 and 6 [1, Table 1] can only be obtained by adding an amount of Rb which *cannot be contained* in the green pellets.

Concerning the two dark-green lobate samples considered in the text as presumably good chronometers giving concordant K-Ar and Rb-Sr ages, Table 3 [1, p. 289] shows an apparent age of 95.2 Ma for sample "3 dgl" which is *not* concordant with the Rb-Sr age of 60.2 Ma.

The discordance of K-Ar and Rb-Sr ages is *not* a sufficient argument to show that the glaucony system is not closed since genesis. The initial apparent age of a little-evolved glaucony [3,5] may be different from zero [7] and different for Rb-Sr and K-Ar systems [15]. Even if closed by burial during its whole history, the chronometer may give different K-Ar and Rb-Sr apparent ages.

The isochrons using samples 7, 3, 14 cannot be called "well defined" as there are in fact only 2 groups of points far from each other. They are not isochrons.

Samples 1, 2 and 13 are *not* "radiogenic Sr-poor samples", they probably have a content of ^{87}Sr equivalent to other samples, but they have a much higher common Sr content probably due to calcium carbonate or to phosphate (insufficient cleaning).

In summary, we emphasize that the difficult problem of dating glauconies can only be approached with (1) a correct knowledge of the characters of the material being dated (the colour and appearance of the grains are insufficient); (2) a complete understanding of the Rb-Sr method of dating when applied to glauconies: true isochrons are very difficult to obtain as the points measured on material correctly cleaned [16], always lie far from the y axis; (3) a correct knowledge of the bibliography on the subject: not one reference is made to works posterior to 1974 in this paper published in 1981!

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References

1 R.L. Montag and D.E. Seidemann, A test of the reliability of Rb-Sr dates for selected glauconite morphologies of the Upper Cretaceous (Navesink Formation) of New Jersey, Earth Planet. Sci. Lett. 52 (1981) 285–290.

2 G.S. Odin and R. Létolle, Glauconitization and phosphatization environments: a tentative comparison, Soc. Econ. Paleontol. Mineral., Spec. Publ. 29 (1980) 227–237; see also [10].

3 G.S. Odin and A. Matter, De glauconiarum origine, Sedimentology 28 (1981) 611–641; see also [2] and [4].

4 G.S. Odin, Remarks concerning glauconitic materials collected during Leg 48, in: Initial Reports of the Deep Sea Drilling Project 48 (1979) 787–789.

5 G.S. Odin, De Glauconiarum constitutione, origine, aetateque, Thèse Doctorat, Université de Paris (1975) 250 pp.

6 G.S. Odin, Results of dating Cretaceous-Palaeogene sediments in Europe, Am. Assoc. Pet. Geol., Stud. Geol. 6 (1978) 127–141.

7 D. Tisserant and G.S. Odin, Datation isotopique de glauconies miocènes d'Afrique du Nord-Ouest, C.R. Somm. Soc. Géol. Fr. 4 (1979) 188–190; M.H. Dodson and G.S. Odin, Argon isotopes in Recent glauconies, Abstr., ECOG VII, Jerusalem (1981).

8 G.S. Odin, B. Velde and M. Bonhomme, Radiogenic argon in glauconites as a function of mineral recrystallization, Earth Planet. Sci. Lett. 37 (1977) 154–158; B.D. Field and G.S. Odin, K-Ar dating of Palaeocene glaucony from north Canterbury, N.Z. Geol. Surv. Rep. G45 (1981) 1–22.

9 J.M. Triat, G.S. Odin and J.C. Hunziker, Glauconies crétacées remaniées dans le Paléogène continental, Bull. Soc. Géol. Fr. 6 (1976) 1671–1676.

10 B. Velde and G.S. Odin, Further information related to the origin of glauconite, Clays Clay Miner. 23 (1975) 376–381.

11 A. Cimbalnikova, Cation exchange capacity of glauconites, Cas. Mineral. Geol. 16 (1971) 15–21.

12 M.H. Manghnani and J. Hower, Glauconite cation exchange capacities and infrared spectra, Am. Mineral. 49 (1964) 586–598.

13 G.S. Odin, J.C. Hunziker, E. Keppens, P. Laga and P. Pasteels, Analyse radiométrique de glauconies par les méthodes à l'argon et au strontium, Bull. Soc. Belge Géol. 83 (1974) 35–48.

14 N. Clauer, Géochimie isotopique du strontium des milieux sédimentaires, Thèse Doctorat, Université de Strasbourg (1976) 256 pp.

15 P. Pasteels and E. Keppens, Comparison of Rb-Sr and K-Ar data as a means to evaluate the reliability of glauconite ages, Abstr., ECOG VII, Jerusalem (1981).

16 P. Pasteels, P. Laga and E. Keppens, Essai d'application de la méthode radiométrique au strontium aux glauconies du Néogène, C.R. Acad. Sci. Paris 282 (1976) 2029–2032.