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Glaucinite formation: discussion of the terms *authigenic*, *perigenic*, *allogenic*, and *meta-allogenic*

By HANS FISCHER¹⁾

ABSTRACT

Terms concerning the varied modes of glauconite formation require careful distinction. *Authigenic* (= in situ formed) glauconite can be morphologically diagnosed by the existence of well-developed cracks on a rough grain surface. Numerical ages from *authigenic* glauconite are consistent with the biostratigraphy.

Allogenic (= detrital) glauconite – provided it is not only locally redeposited – is finally deposited in a sediment away from its place of formation. *Perigenic* characterizes glauconite that is subjected to short-distance transportation (= resedimented) in a similar environment. *Allogenic* as well as *perigenic* glauconite pellets are spheroidal, ovoidal or well rounded and have a polished surface. They may show scars of residual abraded cracks. The radiometric “ages” of these glauconites exceed in general their geological ages.

The term *meta-allogenic* applies to transformation of *allogenic* layer silicate to glauconite in the marine environment. This term differentiates between the two antithetic terms “authigenic” and “allogenic” and from the more restricted term “perigenic”. Biotite relics in the interior of *meta-allogenic* glauconites are the cause for the elevated numerical ages.

ZUSAMMENFASSUNG

Die Bezeichnungen der unterschiedlichen Arten der Glaukonitbildung verlangen eindeutige Definitionen und Abgrenzungen gegeneinander. *Authigener* (= in situ gebildeter) Glaukonit kann durch gut ausgebildete Risse an der rauhen Kornoberfläche morphologisch leicht diagnostiziert werden und das numerische Alter von *authigenen* Glaukoniten stimmt mit der Biostratigraphie überein.

Glaukonit, der aus einem externen Liefergebiet stammt oder aus älteren Formationen erodiert wurde, wird als *allothigen* (= detritisch, eingeschwemmt) bezeichnet, vorausgesetzt, dass es sich nicht um lokal umgelagerten Glaukonit handelt. Als *perigen* wird Glaukonit bezeichnet, der innerhalb des gleichen Milieus einem kurzen Transport unterworfen wurde (= resedimentiert, umgelagert). *Allothigene* wie auch *perigene* Glaukonitkörner haben eine polierte Oberfläche und sind von gut gerundeter, sphärischer oder ovoidaler Form. Von den ehemaligen Rissen sind meistens nur noch «Narben» sichtbar. Die numerischen Daten («Alter») sind generell zu hoch.

Der Term *meta-allothigen* kennzeichnet die Umwandlung von *allothigenem* Schichtsilikat zu Glaukonit in marinem Milieu. Die allgemein zu hohen numerischen Daten der *meta-allothigenen* Glaukonite werden durch die im Korninneren liegenden Biotitrelikte verursacht. Die Bezeichnung *meta-allothigen* differenziert zwischen den zwei antithetischen Begriffen *authigen* und *allothigen* und dem restriktiveren Term *perigen*.

RÉSUMÉ

Afin de reconnaître les différents modes de formation de la glauconite il est nécessaire d'y appliquer une terminologie précise et distincte. La glauconite dite *authigène*, c'est-à-dire formée in situ, peut être aisément identifiée par

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la présence de fissures bien marquées à la surface du grain. L'âge numérique de la glauconite *authigène* correspond à la biostratigraphie.

On appelle *allothigène* la glauconite qui provient d'un domaine extérieur au milieu de dépôt; c'est une glauconite détritique, finalement redéposée dans un sédiment distant du lieu de formation. On appelle *périgène*, la glauconite soumise à un court transport dans le même milieu de dépôt; il s'agit donc d'une resédimentation ou d'un remaniement local. Les glauconites *allothigènes* et *périgènes* présentent une surface bien polie avec des grains de forme sphérique, globulaire et ovale. En général, les âges mesurés sont trop anciens.

Par le terme *méta-allothigène*, on désigne la transformation en milieu marin de la phyllite *allothigène* en glauconite. Les âges, en général trop élevés dans les glauconites *méta-allothigènes*, sont liés à la présence de reliques de biotite à l'intérieur des grains. On distingue donc, au moyen de ces différentes expressions, les deux concepts opposés: *authigène* et *allothigène* ainsi que le terme plus restrictif de *périgène*.

Introduction

Since the discovery of glauconite in marine sediments, theories for its origin have been controversial. In the earliest studies glauconite was generally interpreted to be of *authigenic* origin formed during diagenesis. Later, the *allogenic* (= detrital) formation of glauconite was discussed. Sporadic reports refer to *allogenic* glauconite derived from older rocks, i.e. glauconite which originates from an external source region. However, there is no quantitative information about the resistance of glauconite with respect to transport.

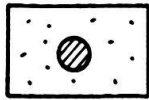
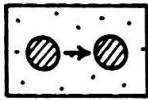
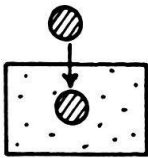
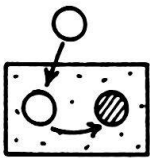
LIGHT (1952) proposed criteria to distinguish *authigenic* from detrital origin; in practice this differentiation is highly problematical due to a lack of a suitable classification scheme. Later, LEWIS (1964) defined the term *perigenic* to characterize glauconite subjected to short-distance transportation in a similar environment to that of its formation. LEWIS (1964) however does not quantify the transport distance, but rather restricts the final depositional environment to the original formation environment. *Perigenic* is thus identical to the modern term 'intraclastic'.

Based on isotopic studies and field evidence on glauconites from the Miocene marine sandstone («Muschelsandstein») of the Swiss Molasse basin, FISCHER (1987) introduced the new term *meta-allogenic* (Gr.: μετα- meta- after; ἄλλοξ- allos- elsewhere; γένεσις- genesis- origin). This term applies to glauconite which has formed from a biotite precursor in the marine environment. This term is confined to a specific sedimentary environment where glauconitization of *allogenic* biotite occurs.

Discussion

In Table 1 a comparison of the four modes of glauconite genesis or place of its formation, respectively, is shown together with the synonyms commonly in use. *Authigenic* glauconite is primarily formed in situ from faecal pellets or from mineral precursors such mica, quartz, feldspar or bioclats (ODIN & MATTER 1981). The main optical criterion of *authigenic* glauconite is the presence of well-developed cracks on the grain surface.

Glauconite that has been deposited in a sediment away from its place of formation is termed *allogenic*. In the literature the synonym "detrital" is more popular than the term "allogenic". Frequently, well rounded, ovoidal and ellipsoidal grains are interpreted as *allogenic* glauconites. However, it is rather misleading to designate all rounded glauconite grains as *allogenic* without close inspection of their transport resis-

authigenic	perigenic	allogenic	meta-allogenic
			
Formed in situ	Formed from an agglutinated clay or faecal pellets and subjected to "short" transportation prior to its final deposition	Formed or generated elsewhere	Allogenic layer silicate subsequently transformed into glauconite

S y n o n y m s :

* autochthonous	* parautochthonous	* detrital
* primary	* resedimented (a)	* clastic
	* redeposited (a)	* allochthonous
	* transported (a)	* allothogenic
		* allothigenic
		* allothigeneous
		* allothigenetic
		* reworked
		* washed-in
		* terrigenous
		* secondary
		* resedimented (a)
		* redeposited (a)
		* transported (a)

R e f e r e n c e s :

Bates & Jackson, 1980 Lewis, 1964

Bates & Jackson, 1980 Fischer, 1987

(a) often unprecisely used in the sense of perigenic or allogenic

Table 1: Modes of glauconite origin.

tance. Because of the generally supposed modest transport resistance of glauconite, rounded glauconite grains could be only of *perigenic* nature. It has not been proven that previously described "*allogenic*" glauconites (e.g. FIRSOV & SUKHORUKOVA 1968; WHITE 1970; LOGVINENKO et al. 1980) are derived from older rocks in a distant source region. The elevated age data obtained by these authors could be the consequence of inherited radiogenic components, as was demonstrated by FISCHER (1987).

Perigenic glauconite is formed from agglutinated clay or faecal pellets or from other mineral precursors such as mica, quartz, feldspar or bioclasts (ODIN & MATTER 1981) and subjected to "short" transportation in a similar sedimentary environment prior to

its final deposition. *Perigenic* glauconites mainly occur in cross-bedded sediments and are characterized by rounded grains.

In the existing glauconite literature glauconitization of various progenitor minerals (mica, quartz, feldspar, bioclasts, etc.) are mentioned. Glauconitization of layer silicates is the most important of these processes for two reasons; 1. It is the most common mode of origin of glauconite; and 2. it is of consequence in isotopic and geochronological studies.

Incompletely glauconitized mica grains contain an inherited radiogenic component which is the reason for too high numerical ages. In contrast, glauconite grains with quartz or bioclast nuclei have no influence on isotopic systems because of the lack of radiogenic components in the nuclei.

First observations of mica-glauconitization were made by HUMMEL (1922), GALLIHER (1935), BURST (1958) and VALETON (1958). Later GYGI (1969, plate 3, Fig. 9 and p. 44), MURAVÉV & VORONIN (1975), ODIN & MATTER (1981) and BORNHOLD & GIRESE (1985) also described glauconitized mica. For the genetic hypothesis of mica transformation a specific term did not exist for a long time. The commonly used descriptions "transformed", "pseudomorphic" and "replaced" only refer to the transformation of glauconite progenitors in general, but not specifically to *allogenic* biotite as a source material. Based on field evidence, microscopic observations and X-ray investigations, *meta-allogenic* glauconite formation occurs in three main steps:

1. transportation of layer silicate (i.e. biotite) from a terrestrial source region into the marine environment,
2. transformation of layer silicate → chlorite → glauconite by complex seawater-mineral reactions and
3. burial.

In contrast to the distinction between *authigenic*, *allogenic* or *perigenic* modes of origin, the identification of *meta-allogenic* formed glauconite is straightforward, provided that biotite relics are preserved in the core of glauconite pellets (see Table 2). Biotite relics are readily identified in grain mounts under the microscope in transmitted light. Recognition of this process is of prime importance for isotopic dating. However, *meta-allogenic* developed glauconite does not necessarily lead to elevated numerical ages. Among the numerical glauconite data of the Swiss Molasse (FISCHER 1987) one sample showed good correspondence with biostratigraphy. Microscopic inspection showed that just this sample contained no visible biotite-relics. Moreover, it is probable that at least part of the Jurassic Oxfordian glauconites which gave numerical ages consistent with the biostratigraphy (GYGI & McDOWELL 1970; FISCHER & GYGI 1987) were formed by the *meta-allogenic* process, as was supposed by GYGI (1969, p. 18). In contrast to the molasse environment, the sedimentation rate of the sampled glauconitic horizons of the Oxfordian in Northern Switzerland was very low. Consequently, there was enough time for a complete glauconitization of biotite.

The terms *authigenic*, *perigenic* and *allogenic* give us only information concerning the place where glauconitization occurred but nothing about the glauconitization process itself, nor of the parent minerals. In addition, apart from the qualitative criteria of the presence or absence of cracks, no significant test exists to distinguish between *authigenic*, *perigenic* and/or *allogenic*. The term *meta-allogenic*, in contrast, answers simultaneously the questions about where and how glauconitization takes place.

	authigenic	perigenic (*) allogenic	meta-allogenic
shape	lobate	well-rounded spheroidal ellipsoidal ovoidal	ellipsoidal spheroidal
surface	rough faint	shiny polished	polished
cracks	often well-developed	often abraded	generally abraded (scars)
interior	free of inclusions	free of inclusions or with relics	biotite relics
numerical ages	consistent with biostratigraphy	elevated	elevated (rarely consistent with biostratigraphy)

The color of glauconite pellets is not a diagnostic criterion. Generally, the color varies from light-green to dark-green to black-green.

(*) In practice, there exist no reliable criteria to distinguish between perigenic and allogenic glauconites.

Table 2: Comparison of the morphology, internal structure and numerical ages of different types of glauconite pellets.

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