

Manganese nodules: genesis, distribution and deep-water circulation

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Abstract: *The genesis of nodules and the notion of “nodule field” are analysed to indicate the interactions between four major factors : topography, sedimentation, Life and water. Then, the major, but badly known role of the deep oceanic currents, is approached by examples.*

Key words: *manganese nodules, deep-sea currents, submarine soils, deep-sea sedimentation, nodule field.*

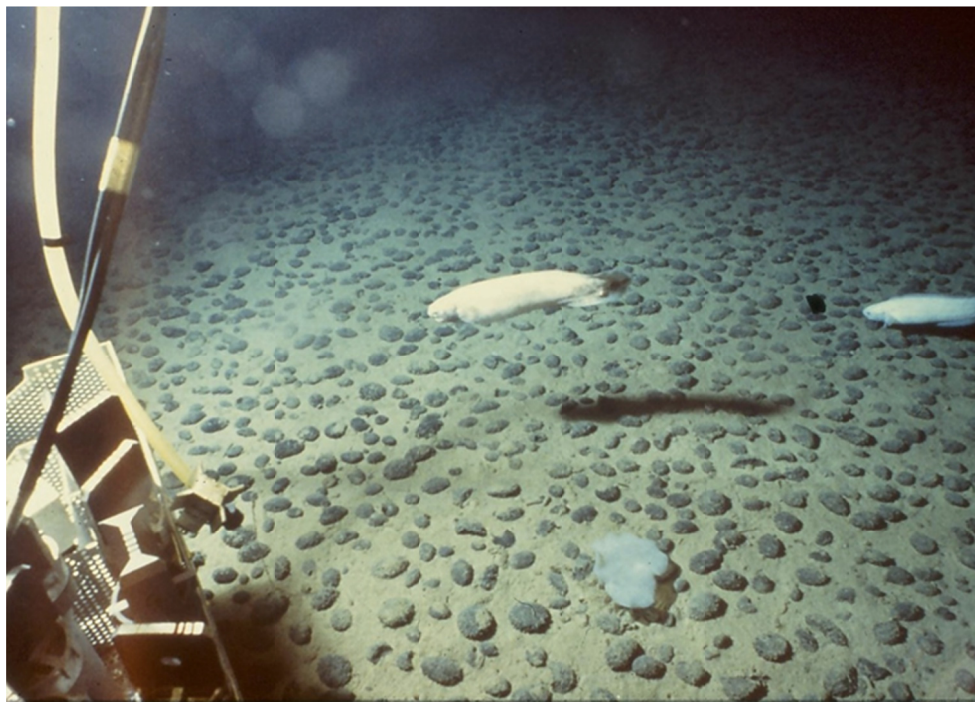


FIGURE 1. Aspect of a nodules outcrop in the Eastern Central Pacific (5135m); on a flat topography, nodules are arranged on soft sediments, associated to life. Currents speed measured in this place was of 5cm/s approximately. The biggest nodules have a diameter of about 10-15cm. (photography : M. Hoffert)

INTRODUCTION

Polymetallic nodules were the objects of intense works during 1970-1990 or so for an industrial exploitation. Then followed a setting in a stand-by mode of these works until recently, a new interest was developed in this potential mining of the future. Recent syntheses allow approaching this new phase of exploration with new concepts (Halbach et al, 1988, Hoffert, 2008 ; ISA, 2009 ; Morgan, 2000).

THE OBJECT NODULE AND ITS GENESIS

The genesis of a nodule requires three conditions: a mobile nucleus arranged in the upper part of soft sediments, a very slow sedimentary deposit rate (1 to 10mm / 1000years) and a lot of time (several million years). The speed of growth of nodules is some millimeters per million years.

Nodules are geological bodies only from sedimentary origins; their formation is a dissolution-

precipitation mechanism associated to a submarine pedogenesis. Nodules can be considered as a horizon of a deep-sea soil. The genesis of nodules is independent from active volcanic phenomena.

No life, no nodules! The planktonic productivity at the oceans' surface is the major factor for the primary sedimentation speed at a point of the ocean floor, which determines the nature of the sediment, the nature and the proportion of the ions in solution by dissolution of the tests. The content in organic matter of superficial sediments influence the mechanisms of diagenesis (phenomena of oxydo-reduction and vertical migration of elements), basis of nutriment; it determines the importance of the benthic life, thus of the bioturbation and the nodules' movement.

THE CONCEPT OF "NODULE FIELD"

The vision of “flat abyssal plains” must be replaced by the vision of a very diverse topography, deriving from the basement tectonics, the variations of

sedimentation, the erosive actions and the sedimentary transport by the deep currents. Nodules distribution results from the interaction of these factors. Thanks to regional surveys (see Halbach et al, 1988 ; ISA, 2009), the concept of "nodules field" was born.

THE MAJOR, BUT BADLY KNOWN, ROLE OF THE DEEP OCEAN CURRENTS

The action of the deep ocean currents has proven to be present in the environments associated to all scales of nodules.

The combined actions of bioturbation and sporadic intensification of the currents, which provokes the erosion, and the re-sedimentation of sediments, can only explain the maintenance of the nodules on surface. The experimental works of Lonsdale and Southard (1974) consider that a speed about 12cm/s is self-sufficient to provoke erosion in zones with nodules.

The discontinuous growth of the nodules is linked to repetitive variations of their sedimentary environment. They translate variations of water bodies in intervals of time from several ten of thousand years.

Great periods of sedimentary hiatuses, as well as the landscapes modelling (like erosion channels - See Cochonat et al, 1992) must have their origin in currents intensifications.

Since the Eocene, large kinematic modifications of plates strongly modified the traffic of oceanic waters. Latitudinarian becomes meridian and is at the origin of deep cold currents. The "nodule time" can then start.

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