Dinoflagellate impact in Petroleum Geology

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Microscopic in size, dinoflagellates are algal unicelles referred to the division of the plant kingdom. They are important constituents of the marine and freshwater biota today and are represented by abundant fossils with sporopollenin in Upper Triassic and younger strata. The pre- Triassic record includes some of the fossils treated as acritach.

After the pioneering works (1836-1940) and the II world war, significant studies of fossil dinoflagellates restarted in the early 1950s. The demonstration of the biostratigraphical potential has been demonstrated at the end of 1950s. Enhanced processing method and improved microscopic equipment at the same time have facilitated research on the detailed structures of polynomorphs. Research on dinoflagellates expanded at the University of Kiel with W. Wetzel, at Tubingen with A. Eisenack, at Paris with G. Deflandre, at Sheffield with C. Downie, at Cambridge with N. Hughes, in Belgium with Pastiels. Their graduate students in both academic and industrial fields described new taxa and investigated the stratigraphic distribution of dinoflagellates from stratotypes in correlation with ammonites, foraminifera and other groups. Then important impetus has been given to the study of dinoflagellate cysts in petroleum exploration, where
their small size, their abundance in many strata deficient in other fossils, and their broad geographic distribution combined with their resistant composition and their rapid evolution made them highly useful in stratigraphic studies. Evitt (1961) worked in the Jersey Production Research Company when he demonstrated that the fossil dinoflagellates were cysts and not motile forms and that the great majority of the so-called “Hystrichospheres” were likewise dinoflagellate cysts.

After 1970s, petroleum geology truly expanded into the oceans and palynology with dinoflagellates became a staple means of correlating submarine sediments. Also, wide-range studies resulted from the international Deep Sea Drilling Project (1968-1983) and the Ocean Drilling Program (1983-2003). Biostratigraphical resolution has increased using origination and extinction with the concept of FAD (First Appearance Dating) and LAD (Last Appearance Dating). Information is now available concerning the sequences of dinoflagellate cysts in all the world’s oceans.

After 1980, both exploration and exploitation programs were greatly enhanced by applying seismic sequence stratigraphic analysis (Vail et al., 1977). Originally founded on the sedimentary interpretation of seismic data, it evolved towards a global concept illustrated by the well known eustatic chart. Bioevents of dinoflagellate cysts have been correlated with sequences and the biochronozones of other groups (Haq et al., 1987; Hardenbol et al., 1998).

3-D seismic and 3-D modelling were two major technological breakthroughs for exploration and production. To provide high resolution sequence stratigraphy, projects linked scientific requirement to industrial reality, have been developed choosing sites that are adjacent to mature petroleum fields from the same strata that were studied in outcrop. Using origination and extinction data of fossils has been supplemented at the reservoir scale, by more subjective local bioevents in the form of First Down hole Occurrence (FDO),
Low Down hole Occurrence (LDO), cyclic events, abundance fluctuations of individual taxa. Traditional multivariate statistical methods are used to refine resolution correlation between wells, wells and outcrops, but sometime without success. Recently a method “the Statistical Modelling of Ecological Signals” (SMES) has been developed using statistical methods that most accurately reflect and quantify the ecological signals
expressed by the cysts (Dale et al. 2005).

Demand for higher stratigraphical resolution in field development studies has been successful in the utilization of new approaches within integrated multidisciplinary teams.

Dale, B. et al. (2005). Statistical modelling of ecological signals: a new method for biostratigraphy, in Recent
Development in Applied biostratigraphy, edited by Powell A. J. and Riding J.B., pp. 179-203, The Micropalaeontological Society.

Haq Bilal, U. et al. (1987). The new chronostratigraphic basis of Cenozoic and Mesozoic sea level cycles. Timing and depositional history of eustatic sequences; constraints on seismic stratigraphy, Special Publications Cushman Foundation for Foraminiferal Research, 24, 7-13.

Hardenbol, J. et al. (1998). Mesozoic and Cenozoic sequence chronostratigraphic framework of European basins. Mesozoic and Cenozoic sequence stratigraphy of European basins, Special Publication Society for Sedimentary Geology,
60, 3-13.

Vail, P. R. et al. (1977). Seismic stratigraphy and global changes of sea level: Part 3, Relative changes of sea level from coastal onlap. Seismic stratigraphy: applications to hydrocarbon exploration, Memoir American Association of Petroleum Geologists, 63-81.

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