REMOTE SENSING CAMPAIGNS OVER THE MEDITERRANEAN

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In modern marine science, classical oceanographic campaigns are increasingly accompanied by remote sensing missions, which extend observations beyond the *in situ* platforms domain and sample the sea surface over a wide range of space and time scales. Such diverse techniques collect mutually exclusive but complementary data sets, all of which are required to properly assess marine phenomena (BARALE and MURRAY, 1992). If surface observations of bio-geo-chemical and physical parameters are performed simultaneously, process interactions can be addressed. And if the processes that generate the observed surface distributions can be determined, inferences based on *in situ* measurements can be made on subsurface properties.

The main features accessible to remote observations of the sea are essentially surface roughness and elevation, temperature and colour. In general, different methodologies may be applied, depending on the objectives and boundary conditions of the observations (ROBINSON, 1985). The structural properties derived from measuremets of surface roughness can contribute to the assessement of dynamical parameters such as winds, waves, wakes, and alterations of the water surface texture due to circulation features, to bottom profiles, or to the presence of surface films (e.g. hydrocarbons). Dynamical properties, expressed by the marine surface elevation with respect to the geoid, provide information on water motion and circulation at large planetary scales, or on deep geological features. Thermal properties, i.e. sea surface - skin-temperature, are related to phenomena of physical, dynamical or climatic nature. Currents, fronts, eddies, upwelling and vertical mixing events, as well as surface slicks of certain kinds, are some of the features described by the parameter temperature. Synoptic assessments of sea surface temperature are also important for circulation modeling, and for balancing energy exchanges at the air-water interface. Optical properties can be used to estimate ocean colour, i.e. the visible spectrum of upwelling radiance as observed at the sea surface. This radiance is related - by the processes of absorption and scattering - to the concentration of water constituents (i.e. planktonic pigments, degrading organic matter, such as the so-called yellow substance, or total dissolved and suspended matter in general). The remote assessment surface colour finds applications in the fields of marine biology and ecology at large, water quality and sediment transport, water circulation and dynamical processes - looking, e.g., at the evolution of pigment patterns and their distribution as related to circulation features, plankton dynamics or coastal runoff and river plumes - as well as in those of energy transfer, carbon cycling and climatology in general. Optical parameters can be used in the evaluation of primary production, which involves the combined knowledge of biomass estimates and a suite of auxiliary data on plankton distribution, properties and physiological state.

As for the concept of remote sensing oceanographic campaigns, a number of orbital sensors have shown their usefulness for providing information on the marine environment on a continuous basis. New perspectives for monitoring dynamics are emerging from the analysis of sea surface roughness data collected by the family of microwave (active) sensors carried by the European satellite ERS-1 - which is the heir of the extremely successful, but short lived, 1978 SEASAT mission and of the GEOSAT mission of the mid 1980's. Optical remote sensing, of coastal zones primarily, has been based historically on high-resolution (pixels on the order of 10's of meters) data collected in the visible/infrared spectral region - e.g. by sensors like the Thematic Mapper (TM), on board the LANDSAT satellites, and the Haute Resolution Visible (HRV), on board the satellite SPOT. However, remote sensing of sea surface colour and temperature, conducted by means of low-resolution (pixels on the order of 1000's of meters) data collected in the visible/infrared and thermal infrared spectral regions, has provided the most interesting data sets for oceanographic applications. Sensors like the Advanced Very High Resolution Radiometer (AVHRR), on the NOAA/TIROS satellite series, and the Coastal Zone Colour Scanner (CZCS), on board Nimbus-7, have assembled outstanding multi-year time series of such data in the 1980's for most of the world's oceans and for the Mediterranean basin as well.

The latest release of an historical archive, which can be considered an oceanographic campaign in its own right, concerns the data set generated by the CZCS, starting in late 1978. The sensor, designed for a proof-of-concept mission that should have lasted only one year, continued to be operated and to collect data on selected oceanic test sites until early 1986, ultimately generating a unique time series of data on the optical properties of the world's ocean surface waters. To this day, the CZCS remains the only ocean colour instrument to have been successfully placed and operated in Earth orbit. The exploitation of the CZCS historical time series is still in progress and will continue to provide a significative statistical reference to future ocean colour assessments.

A complete European CZCS historical archive has been generated in the framework of the Ocean Colour European Archive Network (OCEAN) Project (BARALE, 1994). The data set covering the Mediterranean Sea and the Black Sea has been used to explore relatively clear, oligotrophic, pelagic regions as well as dynamic, mesotrophic, at times even eutrophic, near-coastal areas and marginal basins. Various fully processed data products are available, including water classification parameters, marine and aerosol reflectances and pigment concentrations systematically remapped, using an equal-area projection, to a standard geographical grid with constant resolution of 1 km. The temporal coverage, in the 1979-1985 period, includes daily, monthly, seasonal and annual time scales. The bio-optical data base collected by the CZCS is integrated by a number of ancillary data sets (meteorological data, ozone concentration, etc.) used to derive value-added information. Corresponding time series of sea surface temperature derived from historical AVHRR data are also available. The data have been processed and archived in support of current research activities, as well as with the aim of preparing suitable tools and structures for the exploitation of future space missions with optical instrumentation (BARALE and SCHLITTENHARDT, 1994).

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TWO DECADES OF DEEP-SEA DRILLING IN THE MEDITERRANEAN : PAST, PRESENT AND FUTURE

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The geological history of the Mediterranean region is very complex and articulated. The Mediterranean sea, as we know it now, consists of two major parts : the western Mediterranean which was formed in post-alpine orogeny time and the eastern Mediterranean which is much older and is considered a remnant of Mesozoic Tethys.

Deep Sea Drilling had a fundamental impact in the scientific exploration of the Mediterranean, with special reference to its evolution in the Neogene (last 24Ma).

The past.

1970. The first drilling campaigns (leg 13 of the Deep Sea Drilling Project) was extremely successfull. Even though in the early days of the project core recovery was not comparable to the present one, and site survey was primitive in many occasions, fourteen drillsites were successfully drilled and cored to a subbottom penetration up to 800 m. The most exciting result was the discovery that in all the major basins explored (Alboran, Balearic, Tyrrhenian, Ionian and Levantine), under a one to several hundred meters thick sedimentary cover consisting of oozes, marls and turbidites of Plio-Pleistocene age, Messinian evaporites were present, indicating subtidal, intertidal and even supratidal conditions. This discovery leads to develop the concept of Mediterranean salinity crisis, and to the formulation of the so-called "deep basin desiccation model".

1975. The second drilling campaign (leg 42A od DSDP) provided additional evidence for the desiccation model by (a) recovering pre-Messinian sediments indicative of open marine deep water conditions both in the western Mediterranean (DSDP site 372, Balearic Basin) and in the eastern Mediterranean (DSDP site 375, Levantine Basin), (b) documenting intertidal to supratidal facies in the Messinian evaporites recovered from the deepest basin of the Mediterranean (i.e. Messina A.P. - 4200 m) and (c) recovering Messinian evaporites in the Aegean sea, north of Crete. Among the most interesting results is the first recovery of basement rocks from the Tyrrhenian sea (DSDP site 373, flank of seamount).

1986. The third Mediterranean drilling campaign (leg 107 of the Ocean Drilling Project) was centered on the Tyrrhenian sea. A transect of seven holes aligned NW-SE across the back arc-basin proved beyond any doubt that its evolution was quite recent and fast, as fast as that of recently explored back-arc basins of the West-Pacific. The main results include : recovery of basement rocks at four drillsites, one with peridotites; first good paleomagnetic calibration of the Plio-Pleistocene succession, discovery of a 500 m thick pile of subaqueous, but non marine (lacustrine) Messinian sediments in the western Vavilov basin; demonstration that the age of marine sediments overlying basement is progressively younger from the western end of the transect (passive margin of Sardinia) to the eastern end (Marsili basin).

Present and future.

A new phase of exploration will start soon and has three major objectives; two of them essentially dealing with the tectonic evolution of the Mediterranean, the third one with paleoceanographic circulation and evolutionnary patterns. One of the tectonic themes deals with the Alboran basin. By drilling a series of holes it is hoped to decipher the extensional history of this basin which is entirely surrounded by orogenic chains. Another tectonic theme is concerned with the Mediterranean Ridge, an accretionary complex in collisional context. The subducting sediment pile is anomalously thick and contains at shallow subbottom depth the Messinian evaporites. As a result of the combination of all these factors, mud diapirism is highly developed.

The 1995 drilling plan includes a transect of (shallow) holes across an active mud volcano, an experiment never undertaken so far. This tectonic objective will be combined with a transect of holes across the Eratosthenes Seamount south of Cyprus, of great geodynamic interest.

The third theme is focused on "Mediterranean sapropels". Sapropels are pelagic, organic-rich sediment layers well known from the late Quaternary of the eastern Mediterranean, poorly known elsewhere. Their origin is controversial with basically two alternatvie models : one relating them to the vertical stratification of the water column, the other one oriented to changes in productivity. The experiment consists in continuous coring (twice or three times, in order to guarantee a complete recovery) 7 drillsites along an E-W transect crossing the entire Mediterranean, where temperature and salinity gradients are known.

The three scientific themes have been combined in two drilling legs (ODP 160+161) for logistic reasons,dealing respectively with the western Mediterranean (the latter) and the eastern Mediterranean (the former). Never before four consecutive months of shiptime were dedicated to the Mediterranean !

We look forward seeing the new results and we do hope they will bring the same scientific excitement that the previous Mediterranean drilling campaigns brought about. But this will by no means be the end of the scientific exploration of the Mediterranean by deep drilling. Indeed, the present step of exploration only comprises shallow targets. Deep targets are not obtainable with the present technology which prevents the penetration of the Messinian avaporites without a riser. If such technology will be made available in the future, a brand new scenario for deep drilling will open ahead of us.