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High activity at gas emission sites across the Nile Deep Sea Fan: geophysical evidence

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During two component expeditions of the multidisciplinary Euromargins project MEDIFLUX in 2003 and 2004, a new field of gas seeps and mud volcanoes on the Nile Deep Sea Fan has been examined in some detail. Discovered and surveyed initially using multibeam techniques (Loncke and Mascle, 2004), a number of targets in (a) the deep ($\sim$3000m) western area, (b) the gas chimneys of the eastern province ($\sim$500-1000m), and (c) the central area of pockmarks and slides ($\sim$2000m) were investigated both from submersible (NAUTINIL expedition) and surface ship (MIMES expedition). Geological controls for different types of active emission sites in the different provinces include the presence or not of underlying Messinian evaporites, superficial faulting from slope instabilities or salt tectonics, and structurally deeper faulting. The western province, underlain by remnants of Messinian evaporites and cut by faults to the evaporites, is characterized mainly by fields of small mud volcanoes, many with craters (some filled with briny mud), and larger calderas (some containing several mud volcanoes). Elevated fluxes of brines with high concentrations of methane and/or hydrogen sulphide are inferred from high temperatures and thermal gradients in the brine pools (e.g. temperatures as high as 57°C throughout the $>$250m deep cauldron of briny mud on the Chefren mud volcano), high concentrations of methane in the water column just above them (e.g. methane peak of 15,000 nmol/L at 2972 m depth above Cheops mud volcano and 41,000 nmol/L above Chefren), and water column gas plumes (inferred from 3.5 kHz profiles over Cheops). Well-defined gas plumes are

also detected by Edgetech DTS-1 deep tow sidescan sonar in the water column above pockmarks in the central region and both the centres and edges of gas chimneys in the eastern province. At Isis mud volcano, over one of the gas chimneys, central temperatures as high as 40˚C were measured at 10 m below the seafloor, diminishing to normal values over a short distance from the centre, as well as methane concentrations of 1,500 nmol/L just above the seafloor, and acoustic 'flares'. Gas and temperature measurements taken less than a year apart indicate the variable and dynamic nature of the seeps. The mud volcanism itself is apparently a less vigorous process here than is the seepage. The surface of the gas chimney mud volcanoes is characterized by concentric ridges and valleys; however in the central region, within a radius of about 100 m, there is a more chaotic microrelief of no more than a couple of metres that causes high acoustic backscatter. Striations visible on the flanks of some small ridges in the central area, combined with lack of bacterial mats (in contrast to plentiful seeps and bacterial maps observed further from the centre on the larger smoother ridges), suggests recent faulting or extrusion. Processes at seafloor seeps and mud volcanoes on the Nile Deep Sea Fan appear to be driven mainly by advection of gas-rich fluids rather than the periodic eruption of mud that builds up mud volcanoes in other parts of the eastern Mediterranean.

Reference cited: Loncke, L., Mascle, J. & Fanil Scientific Parties, 2004, Mud volcanoes, gas chimneys, pockmarks and mounds in the Nile deep-sea fan (eastern Mediterranean); geophysical evidences. *Marine and Petroleum Geology*, **21**(6):669-689.