THE ACTIVITY OF MAIN BELT COMETS M. T. Capria[1], S. Marchi[2], M. C. De Sanctis[1] and A. Coradini[3] [1]INAF-IASF, Area Ricerca Tor Vergata, 00133 Rome, Italy, mariateresa.capria@iasf-roma.inaf.it, [2]University of Padua, Padua, Italy, [3]INAF-IFSI, Area Ricerca Tor Vergata, 00133 Rome.

A newly discovered class of objects: Main Belt comets (MBC) are recently discovered objects that are orbiting in the Main Belt and are showing cometary activity [1], [2]. These objects are peculiar because their cometary activity is coupled with a Tisserand invariant Tj>3, implying an asteroid-like orbit stable since very long time. Four of them are known until now: 133P/Elst-Pizarro, P/2005 U1 Read, 176P/LINEAR, and P/2008 R1 (Garradd). Many more, currently inactive or faintly active, are probably existing.

Dynamical transition from outer Solar System is nowadays infrequent, and the orbits of MBCs are stable: they should have formed in the Main Belt, or be there since a lot of time. According to new numerical simulations [3], volatile-rich bodies in the asteroid belt may have been arrived from the outer solar system, as a result of planetesimal perturbations triggered by the outward migration of giant planets, about 3.9 Gyr ago. A large fraction of bodies in the Main Belt-belt (up to ~20%) could have such an origin.

Modeling the Activity: If we assume that MBCs are comet-like bodies, that is they are composed by a mixture of ice and refractory particles, a good explanation for the triggering of observed activity is a recent impact. Following a method described in [4] we can estimate the average time of formation of a crater on Main Belt bodies with sizes similar to the known MBCs. For a porous body with a diameter of 5 km and a density of $1g/m^3$, the crater formation rate in the size range 10-20 m is 281 years, while in the size range 100-200 m is 0.11 Myr.

The formation of such craters should be able to expose fresh material buried at a depth of several 10s of meters (ice must have been stabilized against sublimation losses). It would be interesting to know which is the dependence of activity on mantle thickness, and once triggered, how long can the activity last. In order to answer we make use of a thermal evolution and differentiation model (Rome model, [6], [7]. The model, able to compute gas and dust fluxes and surface erosion, is applied to P/2005 U1 Read and P/2008 R1 (Garradd).

We are ssuming that: 1) MBCs are comet-like bodies, that means a porous intimate mixture of ices and refractory particles; 2) an impact has recently happened and a devolatilized mantle with given thickness (from 0 to 5 m) is found on the surface. Models with different mantle layer thickness were ran, to determine possibility and duration of an active phase.

Results: In the case of an impact exposing ice on the surface, from the results of the thermophysical model we see that erosion per orbit is 1 m for P/2005 U1 Read (2 m in 10 y) and 2 m per orbit for P/2008 R1 Garradd (4 m in 10 y).

We are now assuming that the impact did not directly expose fresh ice, but reduced the depth at which buried icy material is found. In this case the heat wave could arrive to the icy layers, activating the body (the mantle is porous). The activity level depends on the thickness of the mantle. Gases sublimate anyway, very slowly. If the mantle is thin, it could be even blown off, directly exposing volatile material. If the mantle is thick, dust flux is almost inexistent, and the devolatilized layer is growing.

In the plot of Fig. 1 the gas flux with different mantle thickness assumptions can be seen (/2008 R1 Garradd). Under a 2 m thick porous dust layer, ~ 2 x 10^6 years are needed to devolatilize 1 m of an ice-rich layer. Model results can be compared with the estimates from observation: dust flux 0.1 kg/s, $Q(H_2O) < 5 \times 10^{25}$mol/s [2].

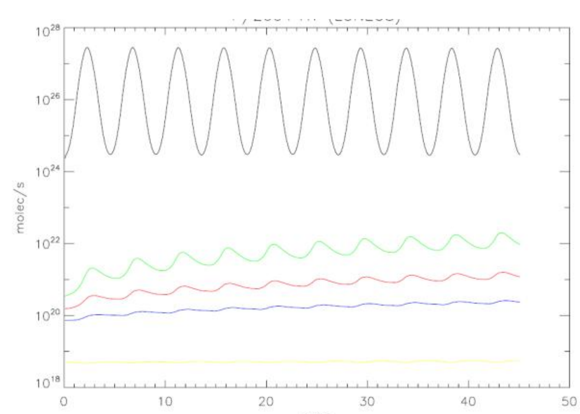

Figure 1. Gas flux for /2008 R1 (Garradd). Black line: no mantle. Green line: mantle 0.25 m thick. Red line: mantle 0.5 m thick. Blue line: mantle 1 m thick. Yellow line: mantle 5 m thick.

Conclusion: It is estimated that an asteroid with a size of 5 km has an average lifetime of 2.2 Gyr (it can be lower for low strength bodies like the MBCs). As a consequence, the observed MBCs are not primordial, but rather are fragments produced by collisional evolution.

A MBC becomes quickly inactive due to rapid degassing of upper layers. Exposed ice lasts very few time (~2 m per year). The same applies to ice buried under a thin porous mantle, while deep-buried ice can last for a very long time. This is also an indication that the observed activity cannot be sustained on "original" bodies, which soon after their injection into the Main Belt became inactive.

In the Main Belt, an impact don't need to necessarily expose ice to activate a MBC: even a very small impactor could activate it, bringing the heat closer to ice-rich layers.

Activity could be due to a catastrophic collision that originated the body (2.2 Gyr). We must also suppose that the body formed almost immediately a thick mantle, protecting ice-rich layers from sublimation. In this case, however, we should see a family for each MBCs.

Our provisional conclusion is that activity is due to a recent collision with a small body and that we are probably in the presence of a cratering event.

References: [1] Hsieh H. H. et al. (2009) *The Astronomical Journal., 137,* 157. [2] Jewitt D. et al. (2009) *The Astronomical Journal., 137,* 4313. [3] Levison H. F. et al. (2009) *Nature, 460,* 365. [4] Marchi S. et al. (2009) *The Astronomical Journal., 137,* 4936. [5] Capria M. T. et al. (2009) *Astronomy and Astrophysics, 504,* 249. 6] De Sanctis M. C. et al. (2009) *Icarus, in press. 504,* 249