



Department of Civil and  
Mechanical Engineering

## Effect of application of Purak devices on the characteristics of calcareous deposits from hard water

Water for domestic and industrial use contains various dissolved salts, among which the calcium and magnesium salts. These are mainly responsible for the hardness of water, the value of which is directly related to the amount of solid that can precipitate in part on the water containment surfaces. These deposits occur either in the form of powders without or with inter-particle cohesion. In the latter case, incrustations are formed with obvious consequences.

Calcium carbonate ( $\text{CaCO}_3$ ) is one of the main constituents of the precipitate, especially for waters with a high temporary hardness characterized by the presence of calcium cations ( $\text{Ca}^{2+}$ ) and bicarbonate anions ( $\text{HCO}_3^-$ ) dissolved in water. Precipitation of  $\text{CaCO}_3$  may be caused by heating or degassing the water according to the following reaction:



Calcium carbonate nucleates in three different crystalline forms (calcite, aragonite and vaterite) which are characterized by different particle morphologies.

The rhombohedral crystals of calcite have high surface area and consequently high interfaces responsible for the formation of more compact coatings on surfaces in contact with water. The needle-like crystals of aragonite, with lower interfaces, form, on the contrary, less compact coatings with consequent little tendency to form hard encrustations on the surfaces. Vaterite crystals with hexagonal structure rarely occur in the precipitates.

The effectiveness of the application of PURAK magnetic devices (produced and patented by Soc. AMS s.r.l of Cassino) on the reduction of hard deposits, was tested and evaluated using *very hard* water samples characterized by hardness values equal to 45 °f (H45) and 76 °f (H76). These water samples have the peculiarity of having a temporary hardness value coinciding with the total one.

Two types of precipitates have been examined. Those deposited on surfaces in contact with water and those formed directly in the bulk of water.



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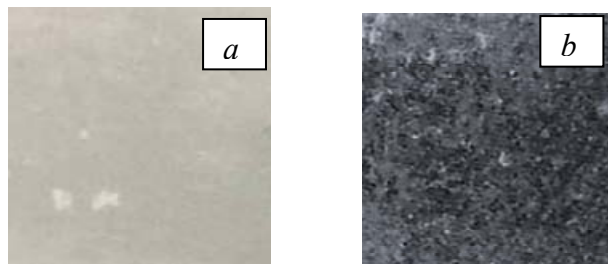
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Such precipitates were obtained by heating at 80 °C or by evaporation at room temperature a same volume of both non-magnetized and magnetized water samples with the PURAK devices.

### *Advantages in the use of PURAK magnetic devices in water H45 and H76 treatment*

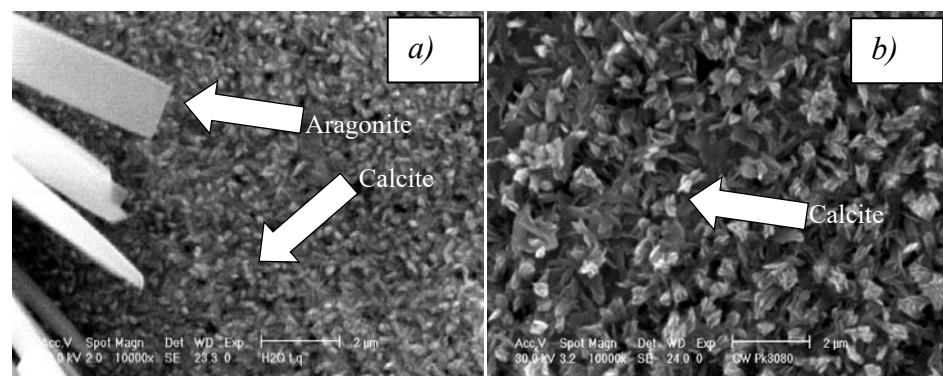
*Heating at 80 °C of magnetized water with PURAK devices determines:*

- formation of deposits with prevalent crystalline calcite on surfaces in contact with water, while aragonite crystals prevail in the precipitates formed directly in the bulk of water. In general, the size of the aragonite crystals is much higher than the crystalline dimensions of the calcite;
- reduction of the mass of calcite deposited on surfaces in contact with magnetized water (Figure 1b) compared to that deposited from the same non magnetized water (Figure 1a). Correspondingly, there is an increase in the mass of aragonite which is formed in the bulk of the water.



**Figure 1** - Calcite deposits on surfaces obtained at 80 °C from non-magnetized water (a) and magnetized with PURAK device (b).

-calcite crystals, deposited on surfaces from magnetizer water (Figure 2b), result larger in size of about one order of magnitude, compared to calcite crystals deposited from waters not magnetically treated with PURAK devices (Figure 2a).



**Figure 2** - SEM micrographs of calcite deposits on surfaces obtained at 80 °C from non-magnetized water (a) and magnetized with PURAK device (b).



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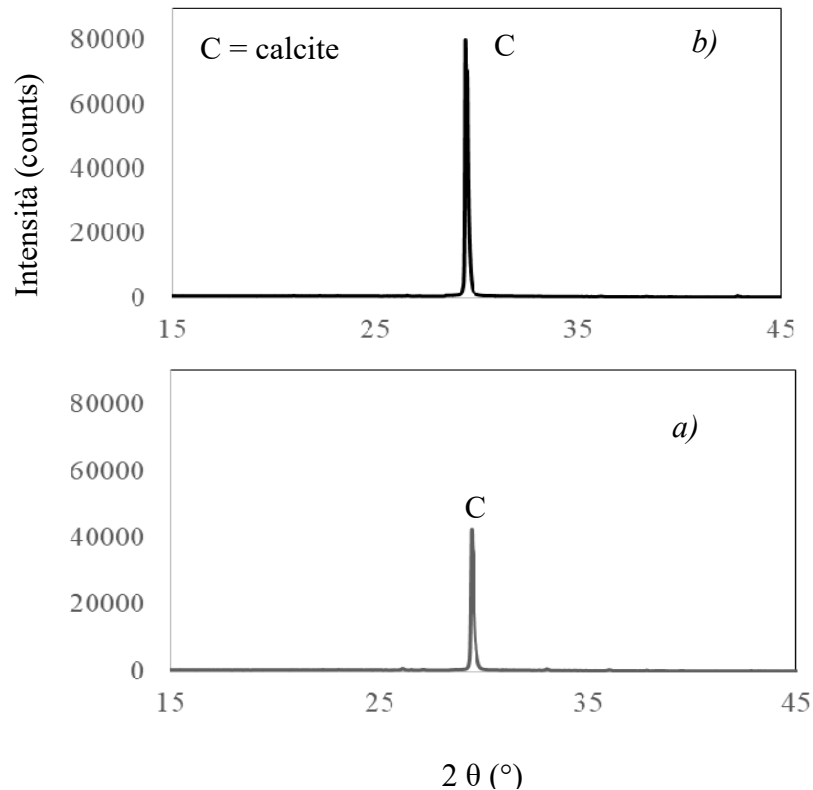
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- increase of crystallinity of calcite deposited on the surfaces from magnetized water with PURAK devices (Figure 3b) compared to that obtained from the same non magnetized water sample (Figure 3a).

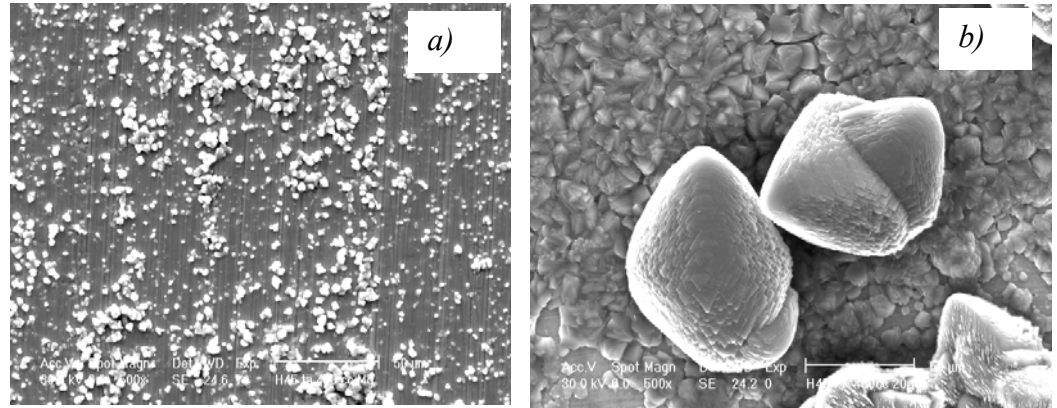


**Figura 3** - XRD patterns in the 15÷45° 2θ range of calcite deposits on surfaces obtained at 80 °C from non-magnetized water (a) and magnetized with PURAK (b) device(b) (b).

- a further growth of the crystalline dimensions of calcite deposited on surfaces and a greater reduction of mass of the same is favored by a *higher speed of water flow* through the magnetic device.

*The evaporation at room temperature of magnetized water with PURAK devices determines:*

- *formation of calcite crystals on surfaces much larger (Figure 4b) than those obtained from non-magnetized water (Figure 4a).* It should be emphasized that at room temperature the dimensions of the calcite crystals on the surfaces, precipitated by both non-magnetized and magnetized water, are much greater than those measured at 80 °C.



**Figura 4** - SEM micrographs of calcite deposits on surfaces obtained at room temperature from non-magnetized water (a) and magnetized with PURAK device (b).

- similar behaviors to those detected at 80 °C.
- minor presence of aragonite in the precipitates in the bulk of the water, related to the lower temperature of evaporation which affects the calcite-aragonite conversion.

The results listed above have been obtained by treating the water sample *H45* with a single PURAK device; while in the case of water *H76*, having higher hardness, the same results were obtained by treating the water with *three* PURAK devices placed in sequence.

### Conclusions

The above characteristics, in particular the formation of calcite crystals larger in size and its reduced mass of the precipitated deposits which result from water treated with PURAK devices allow the formation of calcite powder without inter-particles cohesion so favoring an *easy removal of these calcite deposits from the surfaces*, as can be seen in *Figure 5*.



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*Figure 5 – Surface deposit of calcite powders without inter-particle cohesion*

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