Migration of the explosion focus within the Lachmine N'Aït El Haj maar (Middle Atlas - Morocco)

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The Lachmine N'Aït El Haj (NHL) is a well-preserved plio-quaternary monogenetic maar-diatreme volcano. It's seated in the Middle-Atlas volcanic province. The maar is a result of explosive eruptions through phreatomagmatic fragmentation that occurs when rising alkali basalt magma interacts with karstic groundwater, cutting the country rocks to make a deep dry crater (110 m).

The maar is surrounded by a low rim of bedded pyroclastic ejecta (60 m). The tephrostratigraphic study of these deposits has been developed to improve the understanding of the pyroclastic facies and depositional processes. It offers insights on the identification of the evolution of the maar from a phreatomagmatic to a strombolian style.

On the basis of the deposits characteristics (the size and the shape of the elements, the bedding, the arrangement, the structure of the clasts…), the study of eight radial sections, allow understanding the succession of the eruptive sequences and the dynamic of each one of them. This provides a preliminary hypothesis on eruptive styles and an overview of the general eruptive history during the NHL formation.

At the bottom of the volcaniclastic sequence, three meters of deposits are composed of lacustrine red tuff; it reveals that an old lake was seated before the volcanic explosion. The red tuffs are overlain by pyroclastic deposits surrounding the maars. Based on the stratigraphic criteria and mechanism of deposition, three main units are distinguished during the volcanic process of LNH, the first and second are related to the phreatomagmatic activity of the maar. The last one from a magmatic (strombolian) activity.

This first unit has seven distinct beds, the distribution and the thickness of which vary according to the intensity of the activity and the localization of the eruptive center; on the NW flank where this unit is very well developed (20 m), it narrows towards the W flank (5 m), as well as on the N flank (10 m). The continuity of the beds, their low dip and the low angle of inclination corresponds to a deposition of high pyroclastic density current (PDC), followed by less turbulent currents (peperitic deposits), presenting some forms of traction. The proportion of the juvenile and accidental lithics is depending on the changes in the water/magma ratio.

The second unit is deposited in unconformity with the first one, forming a lateral discontinuity with a thickness reduction in the N and W flanks compared to the NW. This disposition describes an invagination of the crater which distorts its circular shape in the NW. It is characterized by its reddish color evoking a proximal deposit, with the presence of cauliflower bombs indicating humid conditions of deposition. It is also distinguished by a specific formation known as "lapilli rich lithic" where the accidental lithics are very abundant. The increase in accidental lithic clasts have a deeper seated origin, it indicates that either the explosion focus down migrated during the eruptive history or that the vent progressively widened, which explains the invagination of the crater in the NW. In the upper part, lapilli tuffs are essentially formed by agglomerated scoria; it is due to the decrease in the proportion of water with a transition of the eruptive dynamic from a phreatomagmatic to strombolian style. These deposits are disturbed by projections of bombs (up to 1 m of height), which meld the lapilli tuffs. The top of this unit is characterized by a thin film of mud cracks and very intense fracturation.

This ultimate unit contains massive breccia tuffs. It consists of fine round scoria, as well as coarse lava blocks and enormous volcanic bombs, forming a lava breccia rich in peridotite nodules of 2 cm and devoid of accidental lithics. The components are welded by the effect of the heat. This facies is a result of falls during a magmatic eruption. Scoria is produced when magma increases and discharged rapidly. The projected blocks and bombs derived from the degassing of magma. It is a typical facies of spatter-cone deposits. These deposits mainly cover the northern and north-eastern flanks, where the size of the elements is more important than those in the small outcrop in the west. This confirms that the eruptive centre of NHL is located more towards the north of the crater. The southern half of the crater is covered by a basalt flow rich in xenoliths from the plateau, which flows into the crater.