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THE KINEMATIC WAVE THEORY: A PRIORITY OF THE ITALIAN GLACIOLOGY (DE MARCHI, 1895)

ABSTRACT: MAZZA A., *The kinematic wave theory: a priority of the Italian Glaciology (De Marchi, 1895)*. (IT ISSN 0391-9838, 1997).

The Italian priority of the kinematic wave theory, developed by Luigi De Marchi as early as 1895 and 1911, is duly recognized. The theory interprets the relation existing between climatic factors and fluctuations of glacier terminus. The theory had been developed disregarding the glacier mechanics, which, at that time, was scarcely understood.

After the developments of the theoretical glaciology, starting from 1948, carried out by English physicists and metallurgists, the kinematic wave theory has been rediscovered by English researchers and used to investigate the flood waves along rivers and the road traffic flow perturbations.

In an improved physical and technical frame, English and American physicists exploited the new kinematic wave theory in glaciology and, since then, the theory is considered fundamental in the physical and mathematical investigation of the glacier fluctuations, with special regard to the evaluation of the response time of glaciers to climate oscillations. It is exactly the evolution of glaciology that, leaving unaltered De Marchi's concepts, confirms the present validity of the kinematic wave theory.

KEY WORDS: Kinematic wave, Continuum mechanics, Materials science, Plasticity, Surge, Computer simulation, Glaciology.

RIASSUNTO: MAZZA A., *La teoria delle onde cinematiche: una priorità della Glaciologia italiana (L. De Marchi, 1895)*. (IT ISSN 0391-9838, 1997).

Si pone in rilievo la priorità italiana della teoria delle onde cinematiche formulata da Luigi De Marchi nel 1895 e nel 1911. La teoria interpreta la relazione esistente tra fattori climatici ed oscillazioni della fronte dei ghiacciai. Essa fu formulata astraendo dalle modalità del moto del ghiacciaio, allora scarsamente note.

Dopo gli sviluppi della glaciologia teorica, a partire dal 1948, ad opera di fisici inglesi, la teoria delle onde cinematiche fu riproposta nel 1955 da ricercatori inglesi ed applicata allo studio delle perturbazioni delle correnti lungo i fiumi ed ai problemi della circolazione stradale.

In un quadro fisico e tecnico più maturo, fisici inglesi e statunitensi riproposero la teoria delle onde cinematiche in campo glaciologico e da allora essa è considerata fondamentale nello studio fisico-matematico dell'evoluzione dei ghiacciai, con particolare riguardo al calcolo del tempo di risposta dei ghiacciai a perturbazioni del clima. È proprio alla luce dell'evoluzione della glaciologia che risaltano le concezioni del De Marchi, sostanzialmente ancora oggi inalterate.

TERMINI CHIAVE: Onde cinematiche, Meccanica dei continui, Scienza dei materiali, Plasticità, Simulazioni al computer, Surge, Glaciologia.

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The Author wants to thank two anonymous reviewers, the contribution of which has strongly improved both form and content of the present paper.

THE KINEMATIC WAVE THEORY: GENERALITY

Aim of this paper is to underline the Italian priority of the theory of «kinematic waves» travelling down the glaciers, established by Luigi De Marchi, and also to enhance its present validity, even after a century from the date of its birth. The theory was developed independently of the glacier flow mechanics and it holds its validity, even after the introduction of material science, plastic deformation theory and continuum mechanics in glaciology, and, since 1958, it is used to explain the glacier dynamics.

Under «kinematic wave», being triggered by an increase of mass in the upper reach of a glacier, it is understood a bulge on the glacier surface which travels along the glacier at a velocity about 4-5 times higher than its average value. The name «kinematic wave» is due to the fact that no dynamical equations are involved in the derivation of its mathematics. The theory applies only to «unidirectional» glaciers (Hutter, 1983).

The physical reality of this event has been proved towards the end of the last century at the «Mer de Glace» (M. Blanc range; Vallot, 1891-1896 in Lliboutry, 1965: p. 629), and, at the beginning of this century, at the Hintereisferner (Austrian Alps; in Lliboutry, 1965: p. 623); more recently a kinematic wave has photographically surveyed at the Nisqually Glacier, Mount Rainer, WA, USA (Veatch, 1969). It is however to be stressed that this event is quite rare in spectacular form [strong increase in velocity in the glacier section interested by the bulge (thickness increase)].

The propagation of a kinematic wave can cause the glacier terminus to advance, if the Summer thermal regimen is close to a steady state. However, in a recent paper on the secular glacier changes in Northern Sweden (Raper & alii, 1996), it is stated that in glacier evolution the accumulation factor is more effective than the temperature-one.