Main Structural Armor Component - Metal - from the Point of View of Latest Scientific Concepts

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Armor is one of the oldest inventions of mankind which appeared and has been improving together with weapons (stones, arrows, darts, spears, swords, sabers, bullets and shells). Quite different materials were used as armor – wood, woven rods, clay, leather, sand and even moistened and solidified salt, and of course metals. Metals may and must be named as the dominating material for armor and armored structures. First of all, we should note a wide range of metals used in armor, and a great variety of their structural application - from single structural elements (cover plates and badges) through whole products (helmets, cuirasses, hauberks) to large-sized structural armor (ships, tanks, trains, cars etc.).

"Metal" is the name of a dominating group consisting of at least 80 chemical elements which corresponds to almost 80% of all presently known chemical elements. Traditionally metals are characterized by a particular solid-state crystal structure and by a number of specific features such as thermal conduction, electric conduction, strength, hardness, glitter, permanent melting temperature. Metals with density up to 5 g/cm^3 are called "light metals", the rest are called "heavy metals". Also such metal categories are known as "noble metals" (gold, silver, platinum etc.), "rare (rare earth) metals", "alkali metals", "transition metals" etc. The number of alloys of metals with other metals or with other chemical elements and compounds is past one thousand and is constantly increasing. The role of metals in the history of mankind does not need any special discussion; it's enough to remember the names of subsequent historical epochs such as "Stone age", "Copper age", "Bronze age", "Iron age".

It is interesting to note the placement of metals in the modern periodical system of elements. As we know, the Periodical Law and periodical system of elements were invented by the Russian scientist Dmitry Mendeleev in 1869. The invention brought Russian science to the front line of international science and still constitutes the pride of our country. However, Dmitry Mendeleev could not explain the underlying cause of periodicity and said frankly: "We don't know the cause of periodicity". Mendeleev's periodic system of elements in its today's form features a whole system of evident faults: insufficiently clear distinction between metals and nonmetals; the place of hydrogen, the problem of Group 8 (when well-known iron found itself in the same group as noble gases); lack of the place for lantanoids and actinoids etc.

Our paper focuses on new suggestions aimed at improvement, or rather, at creation of a new Periodic system which is caused by the necessity to eliminate the faults of the existing system. The new suggestions are based on the use of all four quantum numbers. The place of each element is clearly and definitely determined by its own combination of four quantum numbers (a kind of personal passport) which is responsible for the quantum equilibrium of the atom as a whole. The system is based on the results of investigation of linear optical spectrums and related to them Pauli exclusion principle, V.M.Klechkovsky and D.N.Trifonov rules and on radical reconsideration of the customary model of atom. The system is called "Symmetric quantum periodic system of neutral atoms", or "Makhov's Tree" by the name of its inventor Boris F. Makhov (Fig.1). The essence of the system is as follows:

The sequence of elements (Mendeleev's row) is maintained, but a new division for periods is introduced on the basis of distinct and clear parameters (quantum numbers).

All periods presented by horizontal rows form dyads with successively increasing number of superstructing horizontal rows (successive one-row, two-row, three-row and four-row pairs of periods, i.e. all in all eight periods).

Length and composition of the periods increase along with increase of the dyad number, forming a kind of "tree".

The new system retains all vertical groups.

In the new system metals and nonmetals are distinctly separated.

In the new system there's a proper place for lantanoids and actinoids.

The problem of Group 8 of Mendeleev's system has been solved.

The new system is a continuous sequence of elements (each element which finishes the previous row, starts the next row, which means that the system can be presented in the form of a 3D model) (Fig.2-7).

Development of the new system required consideration of the neutral atom model and has led to development of a radically new model of atom structure which has been called "Oscillatory resonance model of neutral atom" (Fig.8). In contrast to the existing model of atom, the new model treats the nucleus as pulsing and generating around itself an alternating electromagnetic field which spreads in the surrounding medium to a depth, strictly typical for each atom, and in this way generating a standing (elastic, coherent) electromagnetic wave. The new model does not imply the notion of a negatively charged particle (electron). At interaction of neutral atoms (chemical interaction) their electromagnetic fields overlap and they transfer to some degree of excitation. In this process selection of partners and particular physical conditions of interaction are very important.

According to the new Periodic system and the new atom model each element is characterized by the radius of propagation of the alternating electromagnetic field, generated by the nucleus, or of the standing electromagnetic wave (atom radius).

The characteristics of atom radius values of the elements in the new Periodic system are presented in Fig. 9, from which we can see that the metal atom radiuses are significantly larger than the radiuses of non-metal atoms. It also explains the nature of high-strength of metal bonds.

Another fact is as interesting: in the new System the main alloying components of steel – carbon and nitrogen – are situated next to each other, at the top and in the centre of the new Table. They are p-elements which feature high bond energy (especially nitrogen; that's why it is present also in all such vital organic matters as proteins, and in all explosives.

As applied to one of the main "title" metals – iron – it can be seen that iron itself as well as the main alloying elements are d-elements (Cr, Ni, Mo, V etc.) which belong to the 7-th horizontal row of the new System.

Going back to the problems of armor materials science, and comparing the properties of most accepted "title" metals of alloying systems – iron (steel), titanium and aluminium – we must specially emphasize the efficiency of using aluminium as the armored hull material (Fig.10) and also note the higher efficiency of composing new aluminium-based alloys as compared to composing iron-, copper- and titanium-based alloys. For example, strength improvement ratio in the comparison "pure aluminium – aluminium alloys" can be in the range of 15-20 whereas it is only 10 in the pair "iron-steel", and only 8 in the pairs "pure copper-copper alloys" and "pure titanium-titanium alloys". Thus, aluminium alloys are worth being considered as very efficient and promising armor materials.

Presently good results has been achieved in both two-component and more complex alloys of aluminium with Mg Si Cu Zn (recently attention has been attracted also to Li Ag) which can be explained by better and varying solubility of these metals in aluminium. Maximum solubility of the element in the solid solution is 17.4 1.65 5.7 82% accordingly. It is known that variable solubility provides thermal hardening (tempering) effect. It can be explained by the metallophysical similarity of the above alloying materials with aluminium which expresses itself in closeness of their atom radiuses to the atom radius of aluminium. In Fig.11 the authors present the forecast of development of aluminium-based high-strength armor materials.

The authors are absolutely sure that the new system of periodization of elements and the new atom structure model offer great potentialities and can serve as the basis for further development of fundamental research in natural sciences and in particular in armor material science.

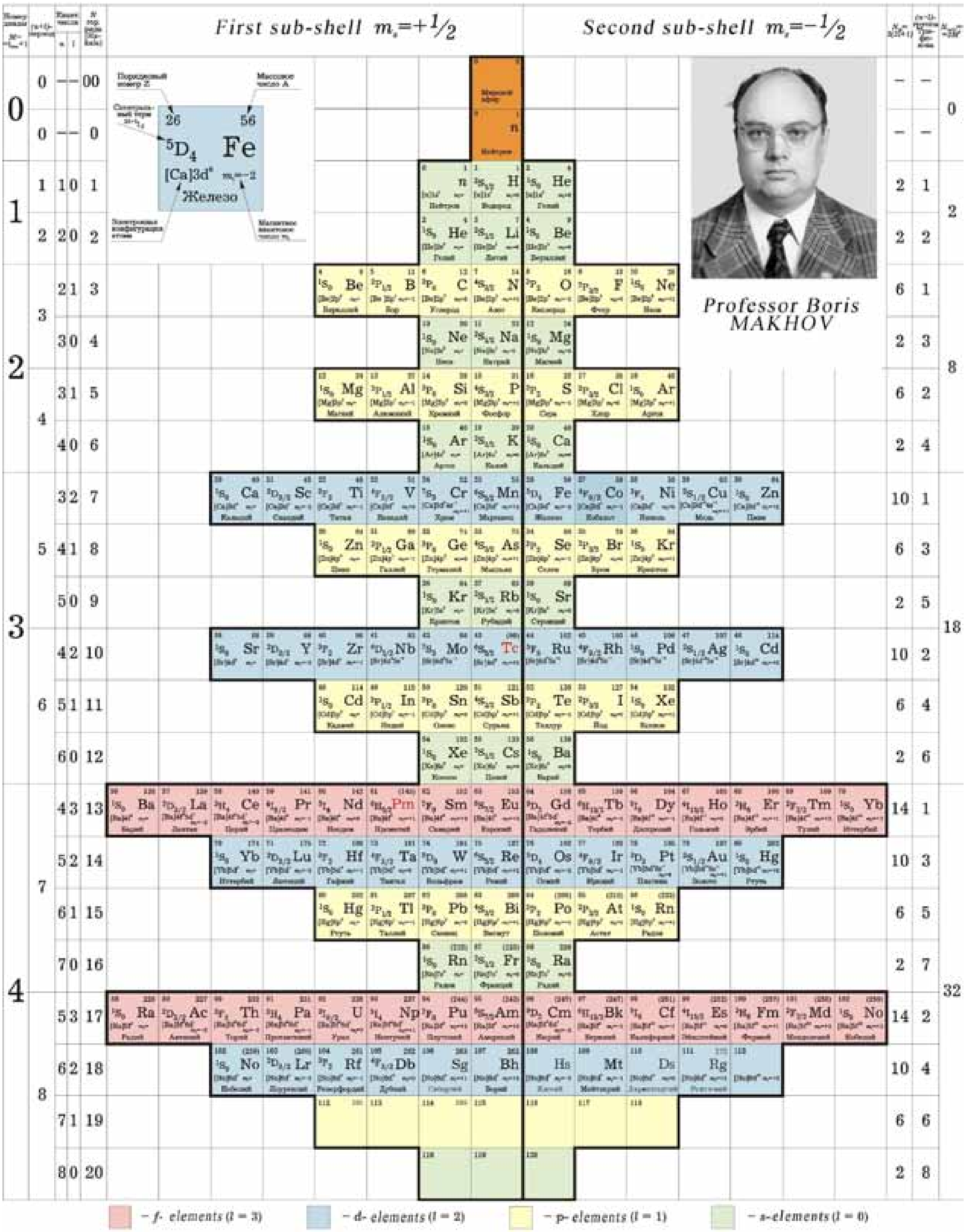

Fig. 1 Symmetrical quantum version of Mendeleev's periodic system of elements ("Makhov's Tree")

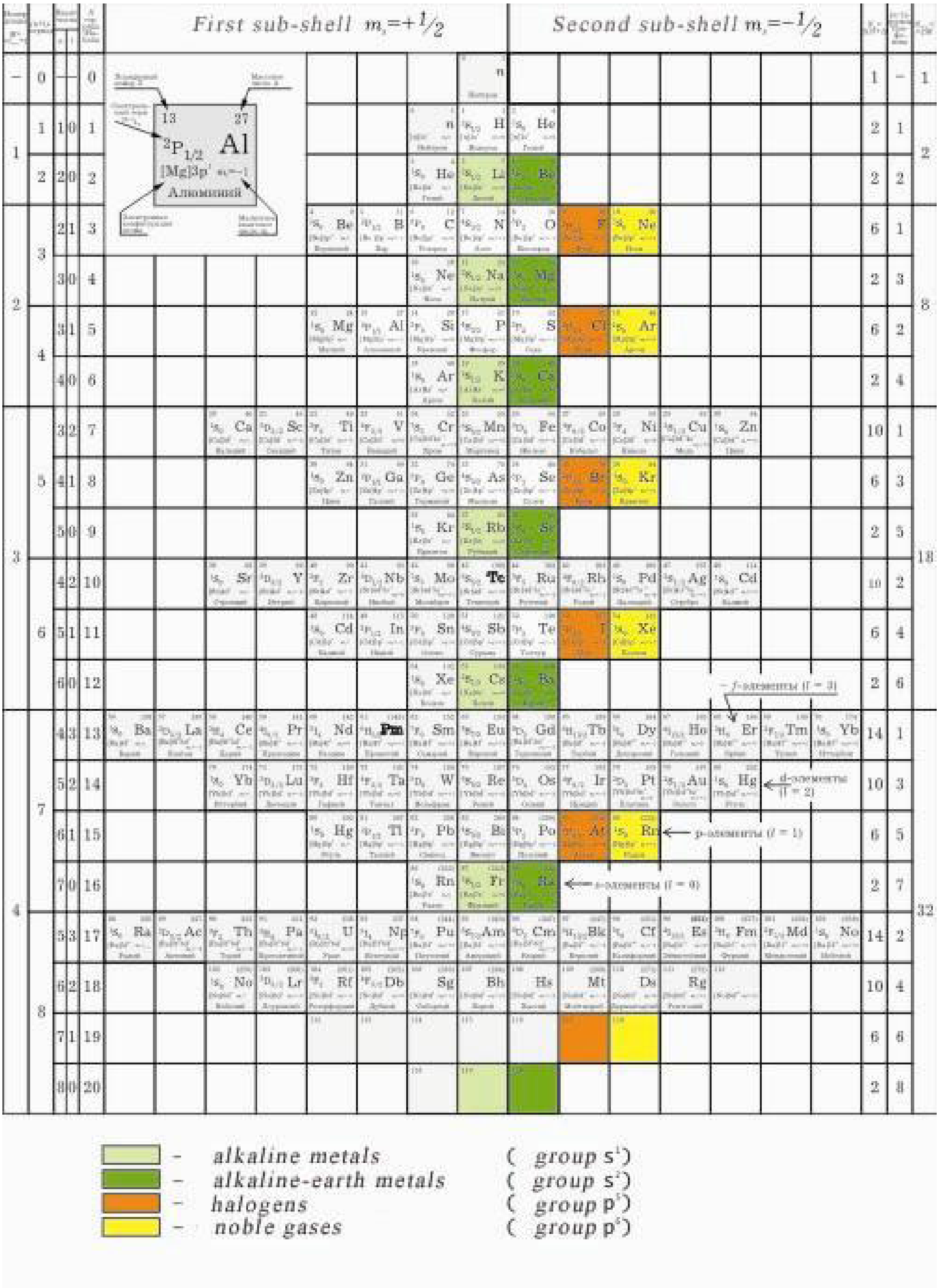

Fig. 2 Distribution of groups of elements in "Symmetric quantum periodic system of neutral atoms"

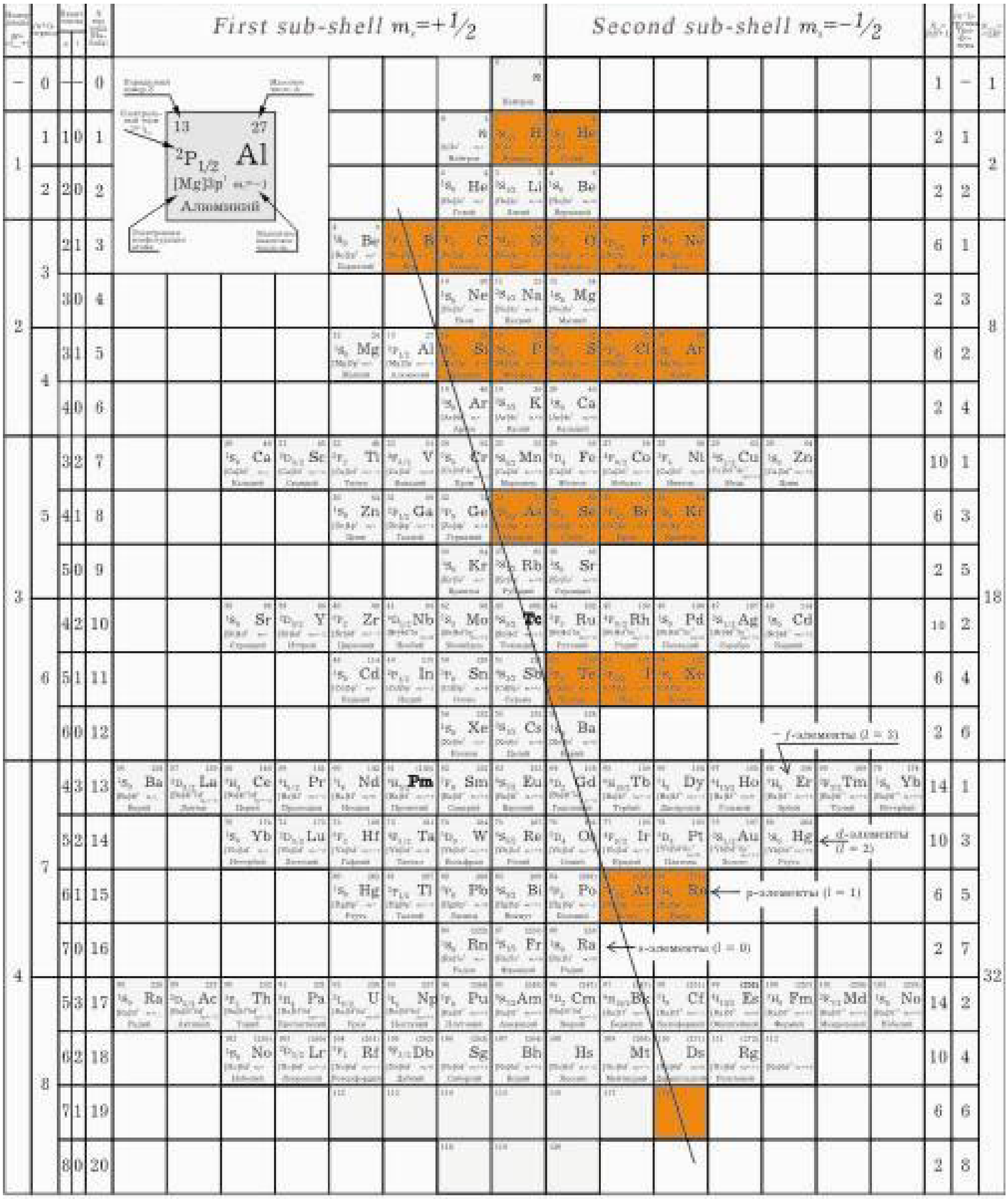

Fig.3 Distribution of metals and nonmetals in "Symmetric quantum periodic system of neutral atoms"

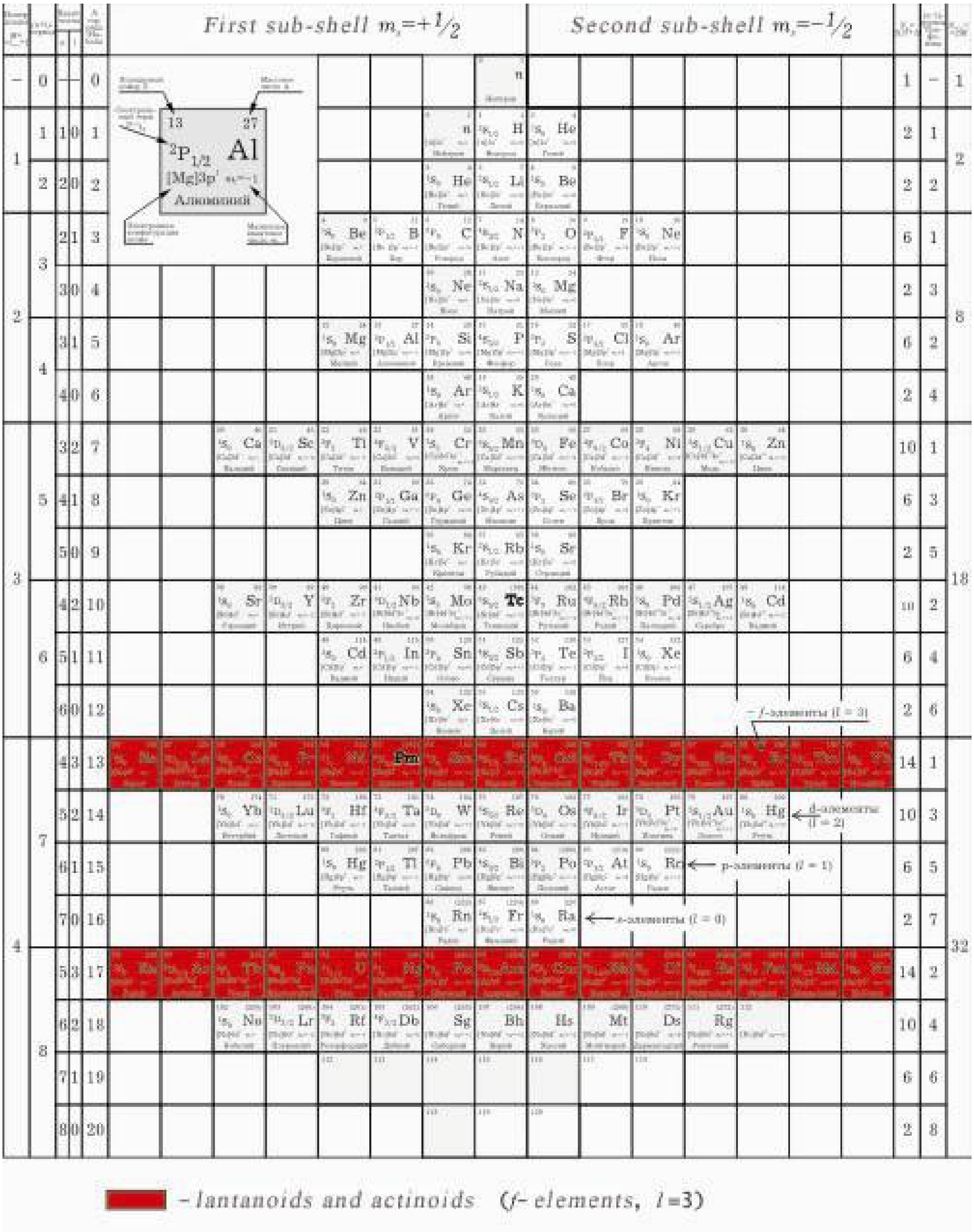

Fig.4 Distribution of lantanoids and actinoids in "Symmetric quantum periodic system of neutral atoms"

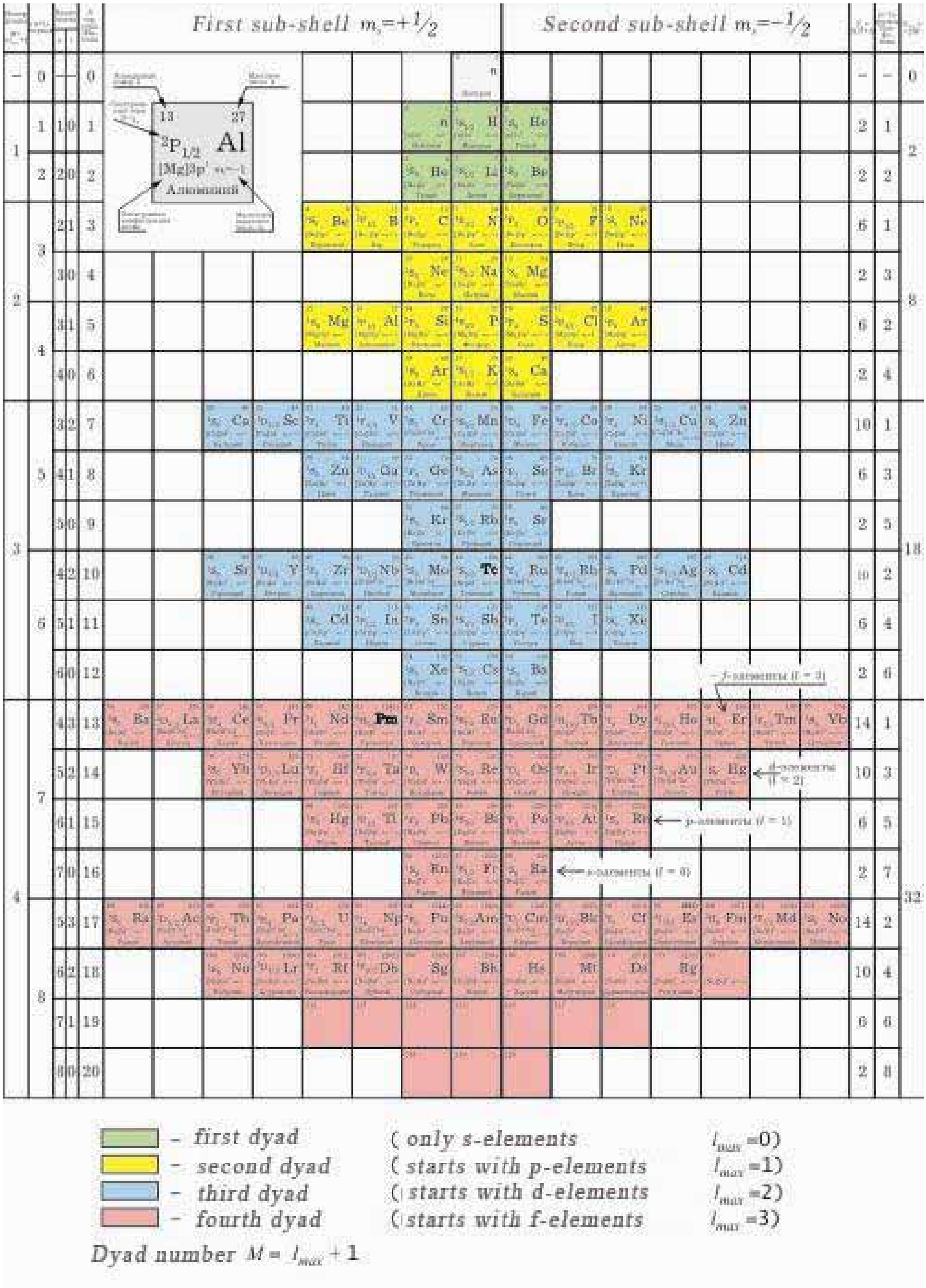

Fig. 5 Distribution of dyads in "Symmetric quantum periodic system of neutral atoms"

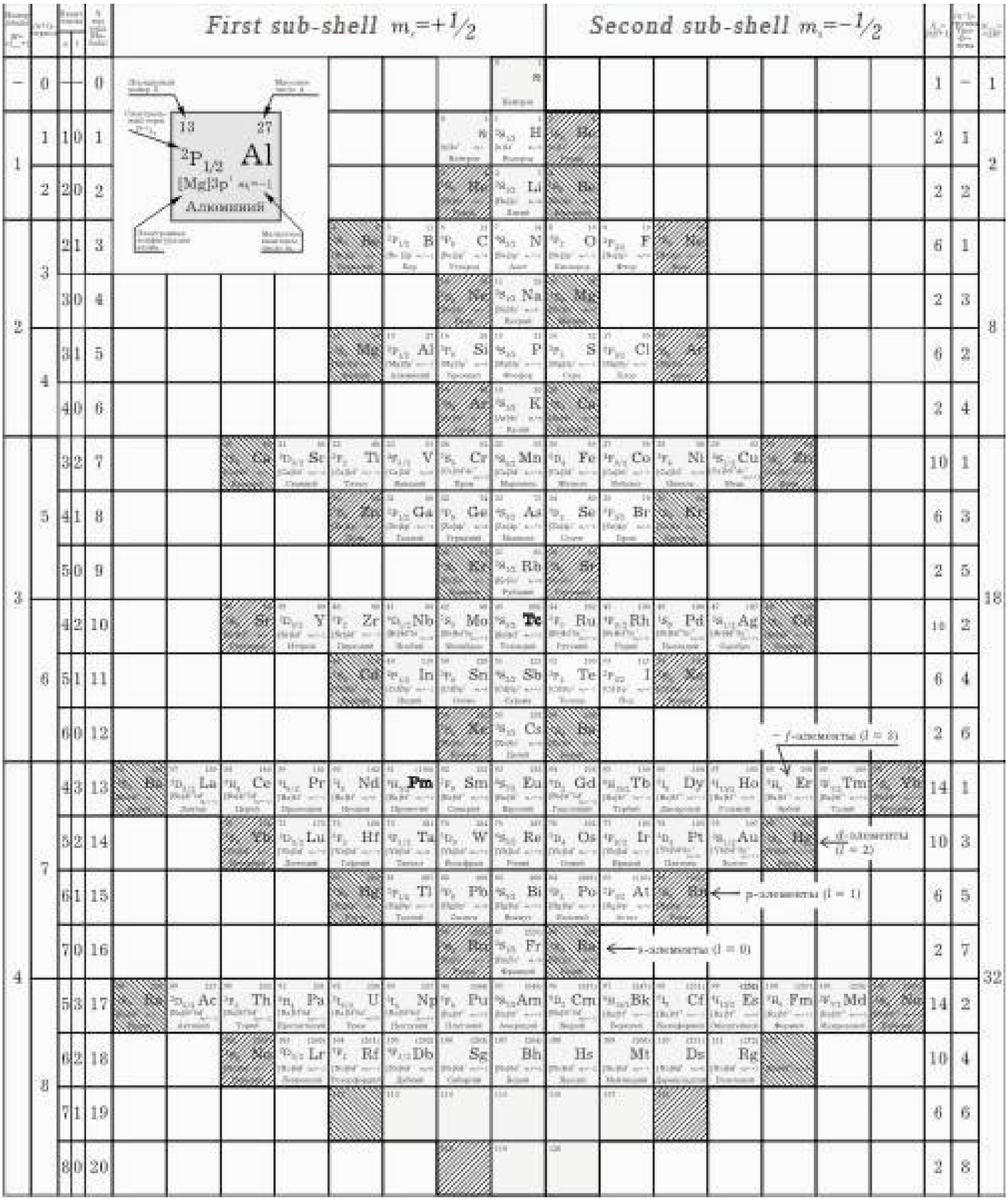

Fig.6 Diagram of relation and continuity of the successive row of elements (each horizontal row starts and finishes with spectral term 1S0)

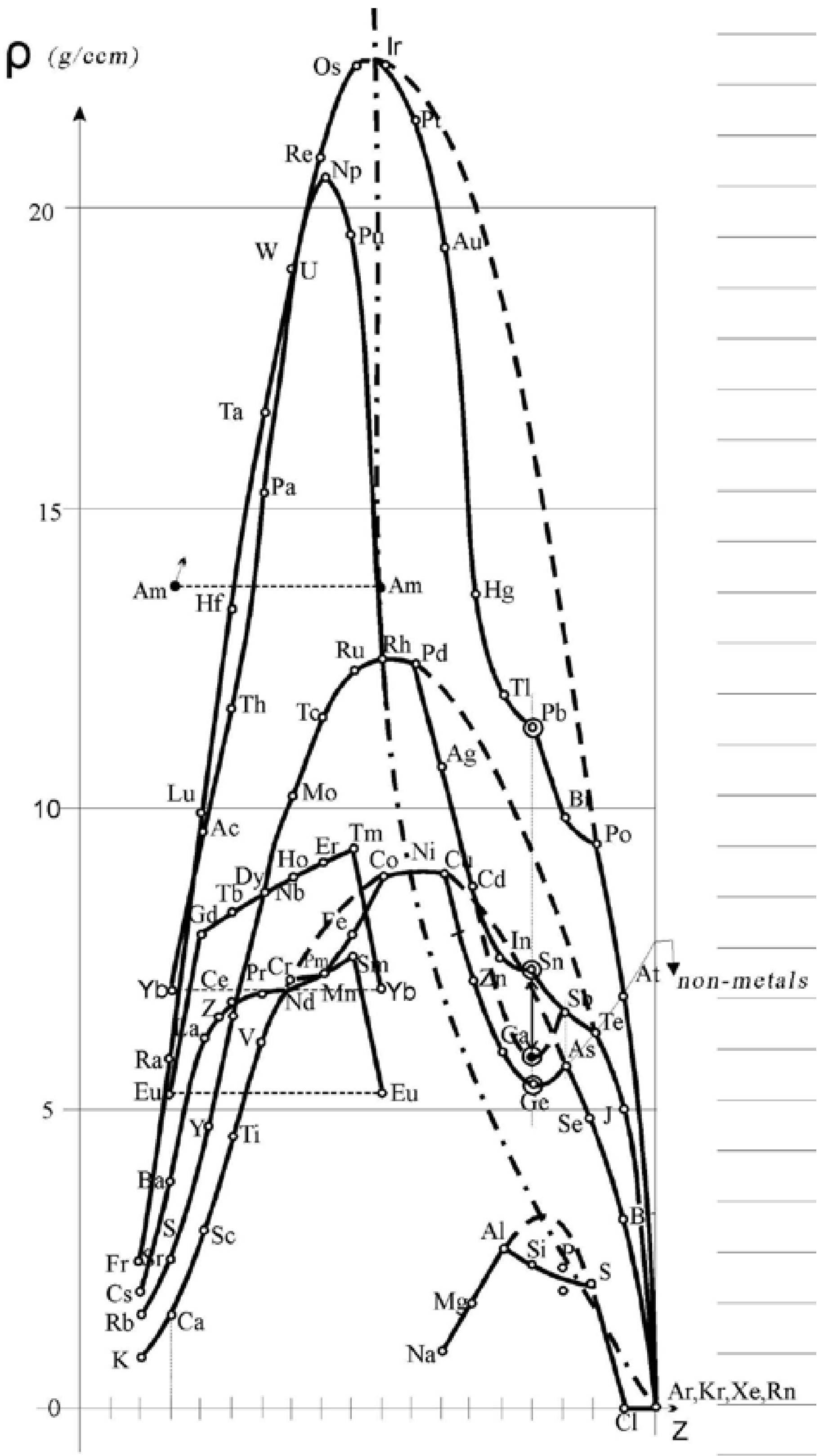

Fig.7 Specific weights of elementary substances formed by particular elements

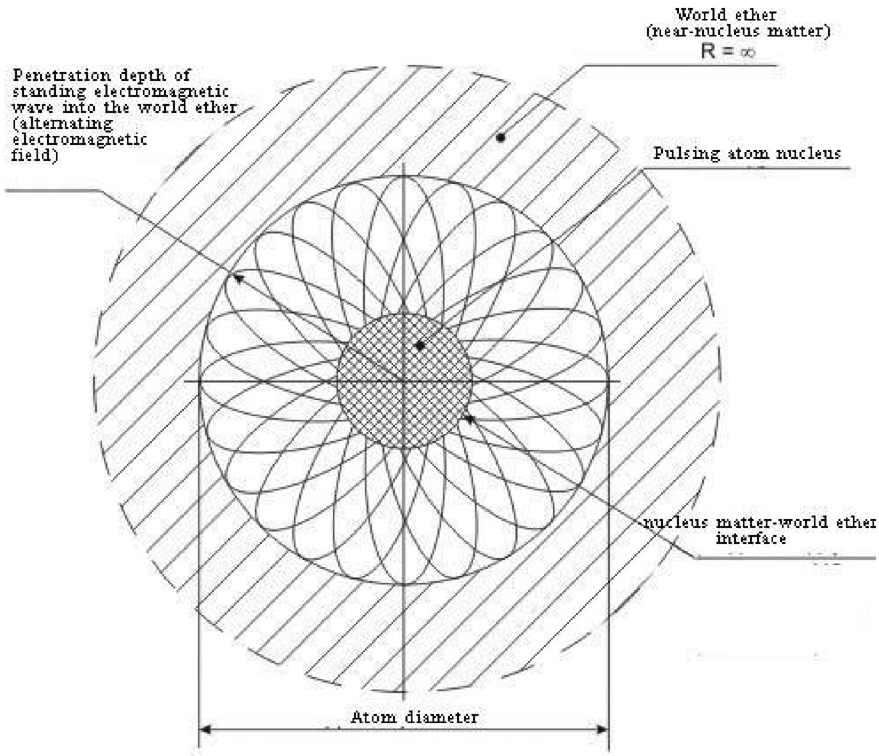

Fig.8 Makhov's oscillatory resonance model of neutral atom

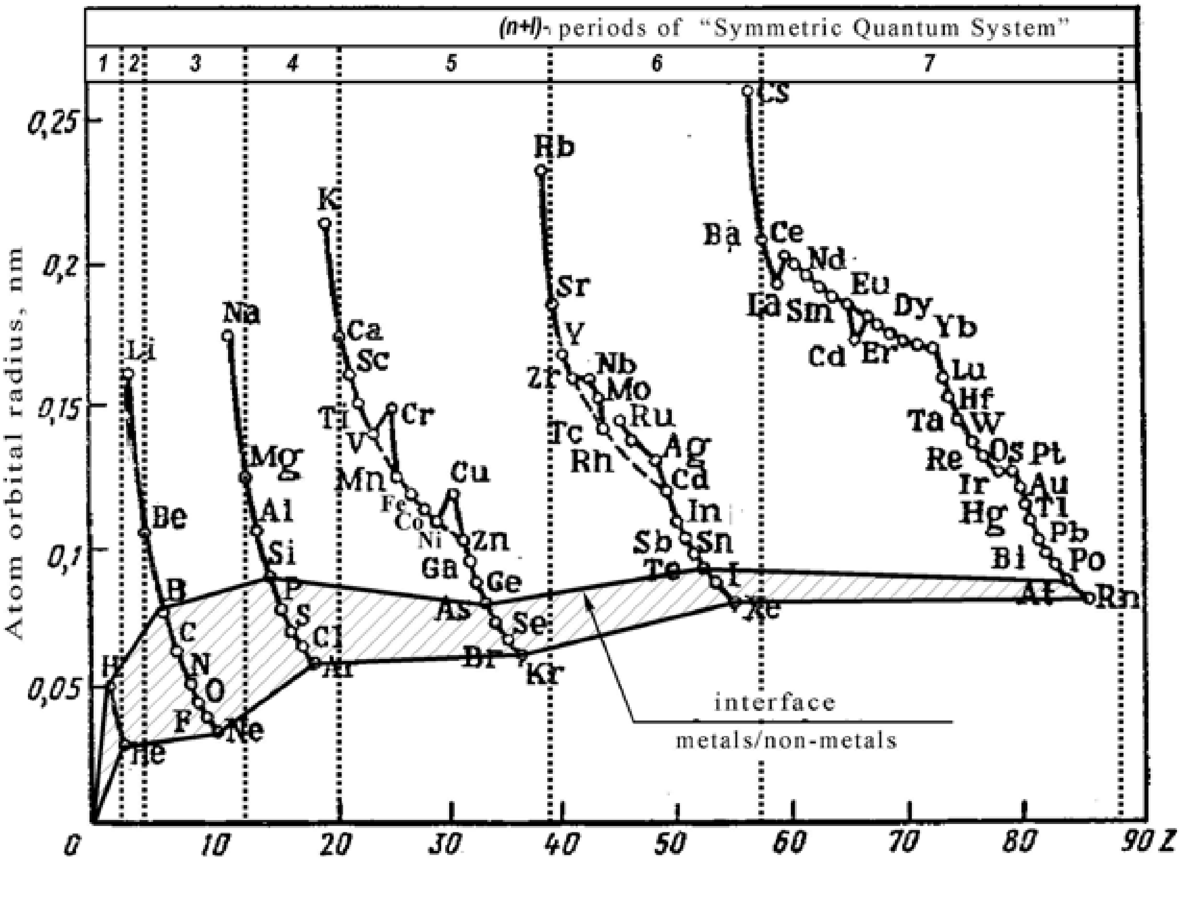

Fig.9 Dependence of the atom orbital radius on the element serial number. The upper line is the interface between metals (above) and non-metals (below).

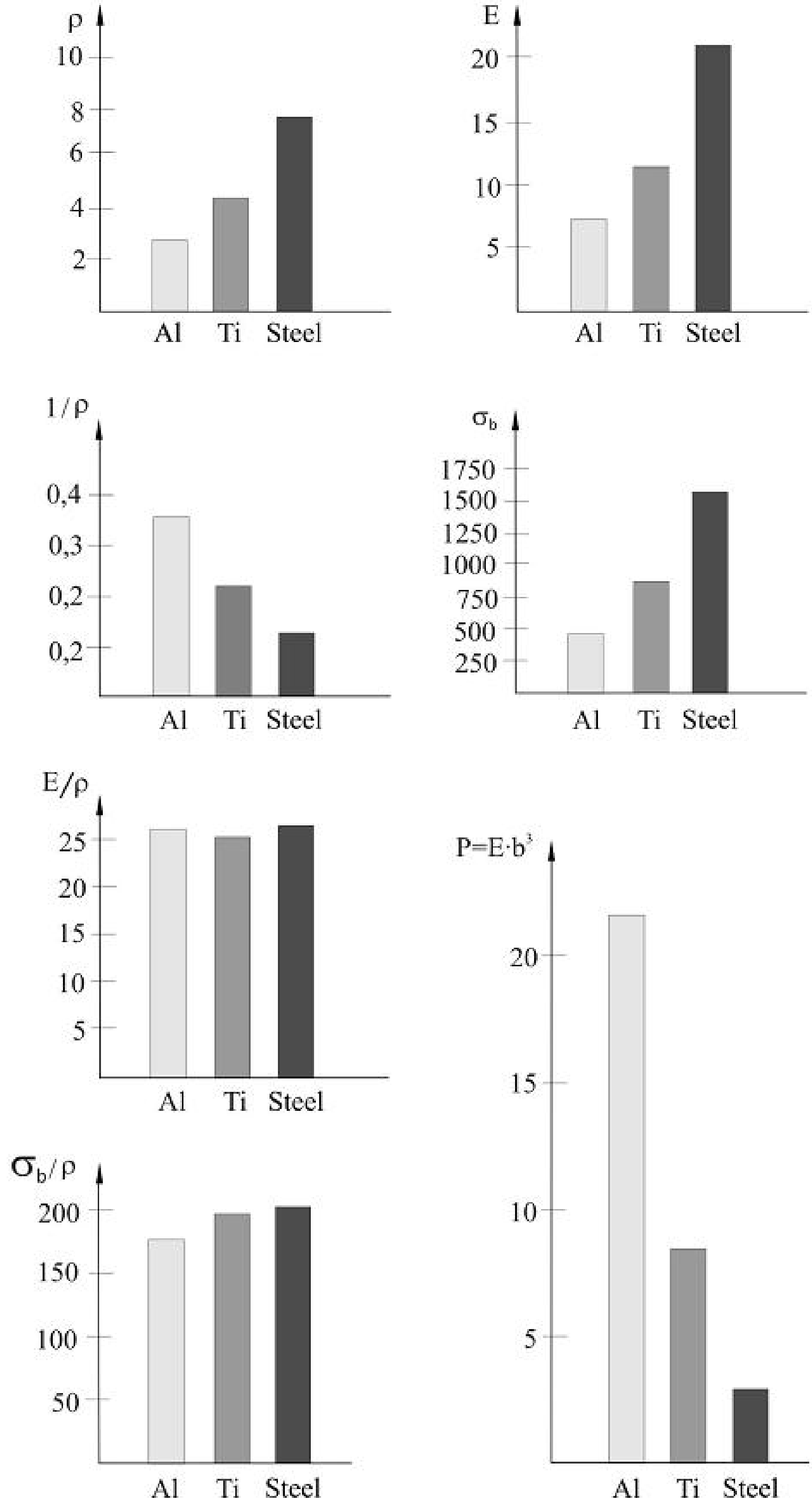

Fig.10 Comparative evaluation of the efficiency of "title metals" application (Fe, Ti, Al) for hull armoring

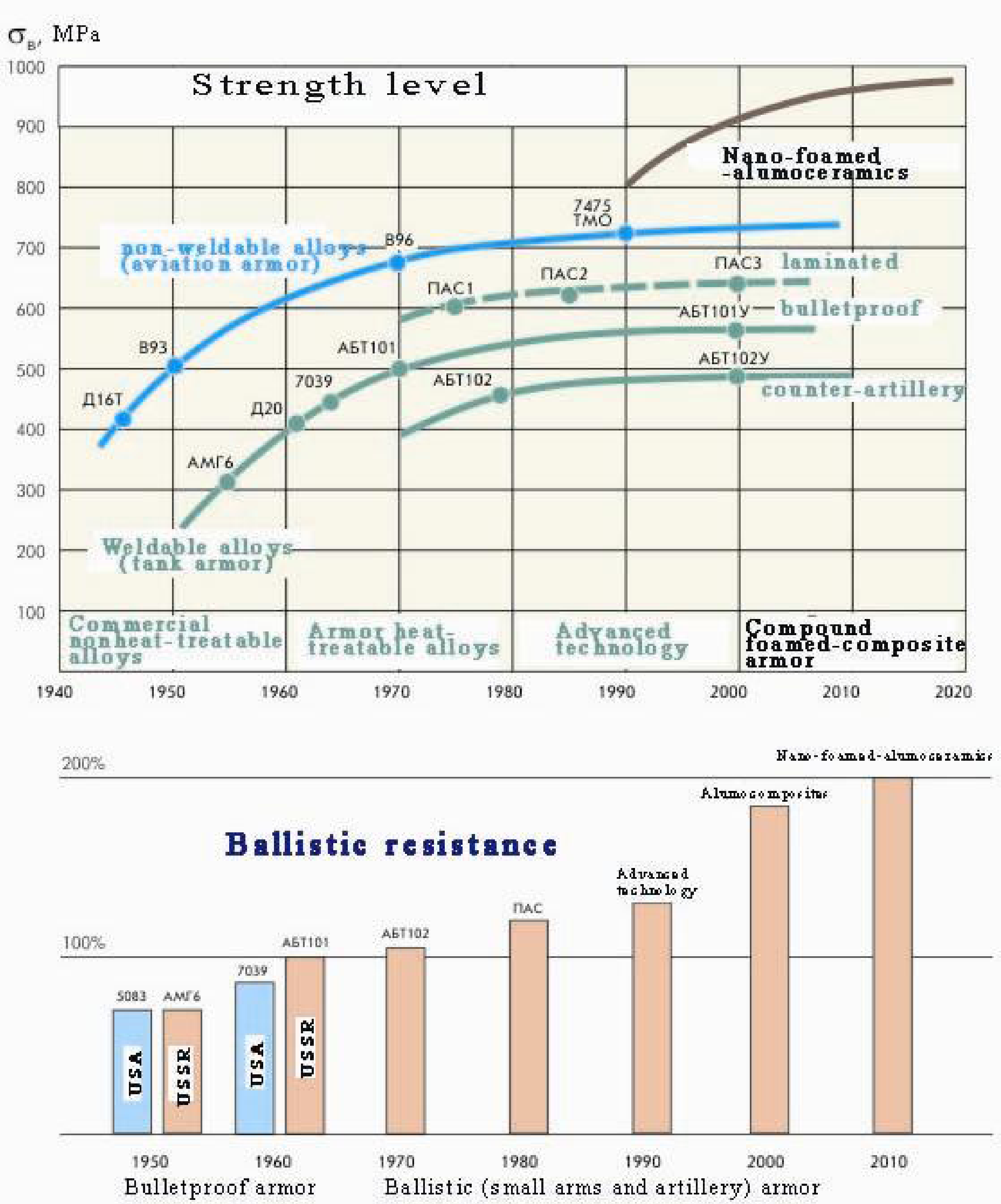

Fig.11 Development of aluminium alloy-based light armor materials