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GEOLOGICAL HERITAGE AND FRAMEWORK LIST OF THE GEOSITES IN TURKEY

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ABSTRACT

Geosites and the special type of geosite called geological heritage are tangible materials such as rocks, fossils, minerals, sedimentary sequences, or structures about which there are results and/or documents of significant events in the geological history. A Framework List deciphers the geological events of the past without mentioning the localities or results. Ideally, there is only one Framework List for every country. The Framework List for Turkey proposed by this study includes 85 titles (frame) in 10 categories. The Stratigraphic and Volcanic-Metamorphic-Sedimentary Petrology categories are the richest for the Frameworks; however they two already contain the majority of the geosites in the JEMIRKO inventory, which contains a total of 815 geosites.

1. Introduction

Even public awareness is not so much, there have been significant changes in research and education on earth sciences since the beginning of the twenty-first century. It seems that problems in finding jobs, unemployment, and excessive disturbance of the natural environment are the leading causes of these changes. It is believed that the second half of the twentieth century will be remembered as the time interval of "heavy destruction of nature"; however, it is also a fact that it is the source of some positive developments at present. Due to the environmental problems resulting from rapid industrialization and overconsumption of natural resources after World War II, IUCN (International Union for Conservation of Nature founded in 1948) started drawing up the the Endangered Species list and the Red List (founded in 1964) as measures to be taken for environmental protection. Although UNESCO's International Convention on Conservation of Cultural and Natural Heritage adopted in 1972 and its application the World Heritage List attracted a great deal of attention, it is not possible to say that they decreased the destruction of nature. Besides, most of these measures had the aim of protecting cultural and biological properties and conserving wetlands, but ignored the earth and non-living properties. The Digne Declaration was issued with the joint signatures of 30 countries in 1991 as an uprising of earth scientists against the increasing destruction of nature. This declaration, which consists of 13 articles, can be qualified as a milestone for geological conservation. Here, it was emphasized that the inorganic part of the globe also urgently needs conservation as it is non-renewable and non-substitutable; it was underlined that some specific rocks, fossils, minerals, sedimentary sequences, geological structures, textures, and so on act as documents about the history of the earth; and the concepts of "geological site – geosite" and "geological heritage" were verbalized for the first time. It is possible to say that the Digne Declaration is a sign of earth scientists' awakening (Barettino et al., 1999 *a, b*).

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Geosite: Natural assets such as specific assemblages of rocks, fossils, or minerals, sedimentary sequences, landforms, geological structures, and so on that reveal an event, process, or occurrence during the evolution of the Earth (Wimbledon, 1996; ProGEO Group, 1998; www.progeo.se). It is like a scientific document about the area.

Geological heritage (geo-heritage): A unique geosite whose disappearance causes the loss of information or a geological document about the relevant area. Some are under threat of extinction (Wimbledon, 1996; Kazancı, 2010).

Although the Digne Declaration has great importance for the improvement and development of studies on geological heritage and geological conservation, it is not the first attempt at the subject. The idea of protecting natural assets that have visual and scientific value can be dated back to 350 years ago, with the efforts made regarding Baumann Cave and Giant Causeway (Burek and Prosser, 2008; Doughty, 2008; Erikstad, 2008). However, these first experiences did not make a lasting impact. At the beginning of the 1970s, similar problems were expressed frequently in Turkey, but they have been forgotten in the years since then (e.g. Ketin, 1970; Arpat, 1976; Arpat and Güner, 1976; Öngür, 1976; Özdemir et al., 1986). The main attempt that resulted in the current developments was the establishment of ProGEO (European Association for the Conservation of Geological Heritage) in 1995. At about the same time, efforts to survey, record, and protect geosites were started in England (Wimbledon et al., 1995, Wimbledon, 1996). The question has been how and by whom geological heritages, of which there are a great number and many types (grouped into ten titles), would be protected (ProGeo Group, 1998). Another important discussion in the same context was held on whether or not to open these geosites to touristic visits. In the same period, the great interest in the World Heritage sites helped conservation of the sites besides causing an economic return to the local people, so that reality generated the ideas of geoparks and geotourism. The Lesbos Geopark (established by Dr N. Zourus) has a special role in that development which was started as the Museum for Fossil Trees in Crete in 1994. The museum declared itself to be a "geopark" in 2000, announced that it had created the Geoparks Network, and led the establishment of the European Geopark Network-EGN (2000) and UNESCO Global Geopark Network-GGN (2002), which are esteemed institutions today. In spite of big efforts on public awareness, concerns about the abuse of science and destruction of nature for commercial purposes will always exist (e.g. Dowling and Newsome, 2005). ProGEO, a well-matured, international non-governmental organization, publishes guidebooks and magazines to set an understanding of geological heritage and geoconservation all over the world (e.g. Wimbledon and Smith-Meyers, 2012) and issues a highly appreciated magazine (Geoheritage). The similar efforts are carried out by the Turkish Association for Conservation of the Geological Heritage, JEMİRKO (2000) (Kazancı, 2010; Kazancı et al., 2012).

Geological heritage and/or geosites are riches of a country and their existence adds value to a region. Their determination (or recognition) requires a high level of geological knowledge and expertise. It is expected that they should be researched, protected, and used for the benefit of society. In this paper, the Framework List (FL) application, which plays a role in the scientific evaluation of the geosites, is presented first and then an FL for Turkey is proposed (Figures 1 and 2).

2. Determination of Geological Heritage

As stated insistently by ProGEO, one of the considerable dangers for geosites, geological heritage, and geological conservation is the attribution of different meanings to these terms. In order to avoid deterioration, we should remain faithful to the original definitions created by ProGEO (Kazancı, 2010; www.progeo.se). The suggestion and acceptance of a geosite depend on rules. Everywhere, only people who have an education in the relevant field can make suggest a natural formation as a geosite or as geological heritage. ProGEO has described the geosites under 10 different categories or groups covering all areas of the earth sciences (ProGeo Group, 1998). These are: a) stratigraphic, b) palaeoenvironmental, c) volcanic-metamorphic-sedimentary petrology, textures and structures, events and provinces, d) mineralogical, economical, e) structural, f) geomorphologıcal features, erosional and depositional processes, landforms and landscapes, g) astroblems, h) continental or oceanic scale geological features, plate relationships, i) submarine, and j) historical and cultural geosites (www.progeo.se).

JEMİRKO has Advisory Committees, each consisting of three persons for every category. According to the method that was adopted during the

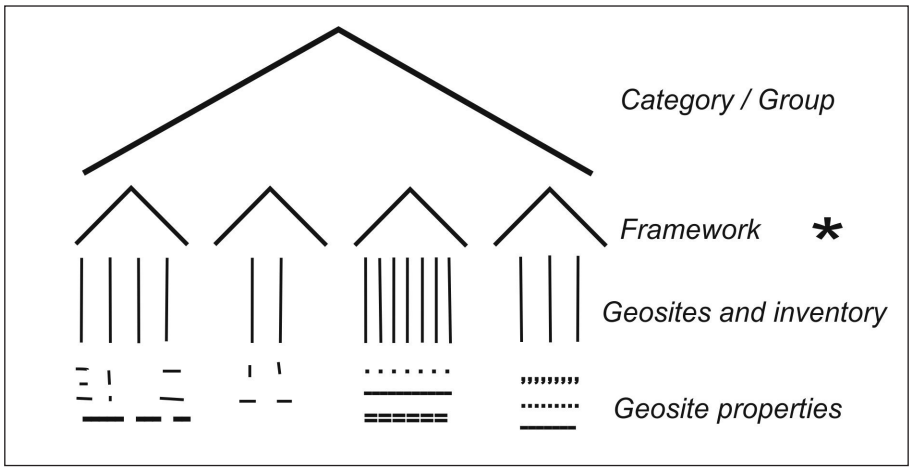

Figure 1- Schematic expression of the conceptual relations between category, frame, FL, geosite, and geosite list (inventory)* suggested by this study.

General Assembly Meeting in 2002 and approved at the meeting of ProGEO Southeastern Europe Countries Working Group (WG1) held in the same year in Turkey, the suggestions of geosite made by earth scientists using the application form are examined by the Advisory Committee of the relevant category. If necessary, members of the committee visit the site. Suggestions that are found suitable by the Advisory Committee are submitted to JEMİRKO's General Assembly. They are discussed there and eventually added to the geosite list. Suggestions that are not approved by the committee are not discussed again. Currently, there are a total of 815 geosites, some of which are in the process of approval (490), in the JEMİRKO inventory. The names and addresses of these geosites are not announced in order to protect them from plunder by collectors.

3. Geosite Framework List

As stated above, geosites are gathered under ten main groups or categories. However, this distinction is far from being informative and is not convenient for detailed analyses; it is only a rough grouping used for further steps. For example, Lake Van, Lake Beyşehir, Lake Eğirdir, Salt Lake, Lake Akşehir, Acıgöl, and Lake Eber are all under the Group f, together with canyons and rivers. The common characteristics of the different lakes is that they are all "wetlands" (a frame). It is obvious that they are considerably different from some other geosites within the same category (*Group f)*, such as the Gilindire Cave, Ballıca Cave, Çatak Canyon, of Köprülü Canyon, according to their features. Collecting the latter under another framework (canyon-valley) makes much more sense (Figure 1). Similarly, Hasandağ, Mount Erciyes, Mount Ağrı, and Karacadağ are different geosites in "*Group c*", but putting them in the framework of "stratovolcano" provides convenience in many aspects. In some cases, however, the geosites under the same category and even having similar origins can be evaluated in different frameworks (Figures 3–5).

In brief, the application of the FL is an attempt to assemble the geosites that are under the same group or category of a country list according to their common geological features (Brilha et al., 2005). The first notable benefit of this application is the fact that a large number of geosites can be classified under the same framework (encouraging the geosite description); the second one is to create an opportunity to compare geosites internationally. For instance, if there are 10 geosites in a country under the "C-T boundary framework", thanks to them the geological changes and palaeogeography of the Cretaceous–Tertiary transition can be compared with each other and also with those of different countries. Such a national and international correlation could provide new possibilities for further interpretation. In short, the FL makes it easier to conduct earth science researches and even encourages them through geosites within the same country and between different countries. So as similar studies spread over the neighbouring countries and gradually all over the world, the Frameworks and their lists (FL) should be similar at least with regard to their main categories (Figure 2). ProGEO calls on every country to create its own FL. It is important to form the FLs in a way

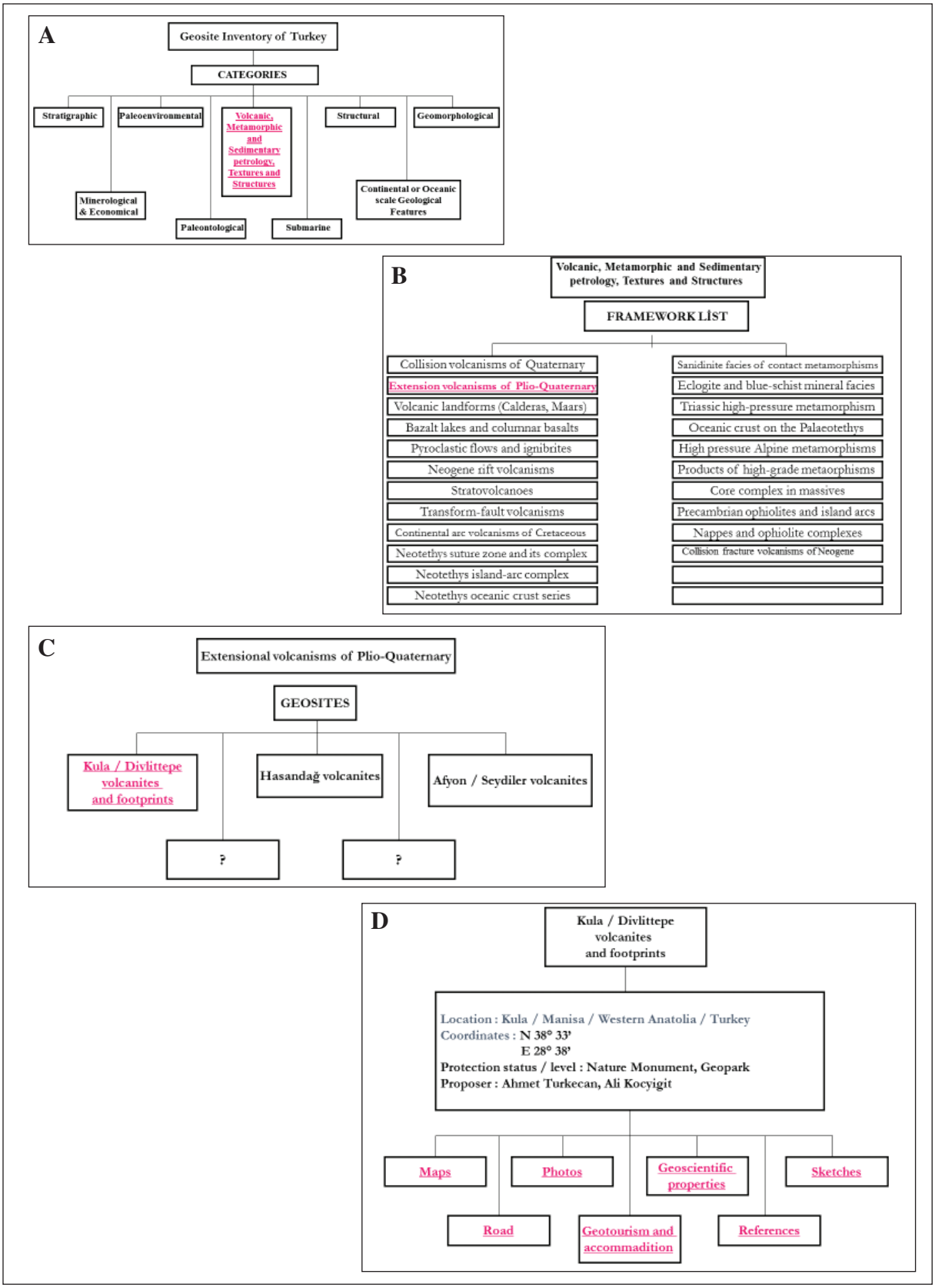

Figure 2- Applied demonstration of the definitions of category, framework list, and geosite: (a) geosite (inventory) categories and selection of one as an example (written in red), (b) the frames in the selected example category (framework list belongs to this category), (c) geosites belonging to the selected frame (written in red), (d) the information in the inventory book belonging to the selected geosites.

Figure 3- Volcanic neck cutting the Eocene units (Yozgat).

Figure 4- Lava channel on tuffs (Afyon).

Figure 5- Aygır maar and its lake (Bitlis).

based on the above-mentioned names of the geosite groups, otherwise there will be confusion again. Regardless of dimension, geographical location, and geological features, each country has only one FL. An FL is not a direct inventory, but it makes an excellent contribution to compiling an inventory (Brilha et al., 2005; De Lima et al., 2010). The extent of the FL is a sign of the geological diversity of a country; nevertheless, during the expansion of the list the main principle is to be very careful and harmonious with neighbouring countries (Theodossiu-Drandaki et al., 2004; Brilha et al., 2005). Ideally, all shareholders in earth sciences all over the country should participate in both the inventory and the FL studies.

4. Suggested Framework List

Despite the fact that the need for an FL for Turkey has been underlined before, it has not been possible to publish a written document regarding this issue (Kazancı and Şaroğlu, 2009). In this study, the following Geosite Framework List for Turkey is suggested (Table 1). The list, which is presented as 85 titles in 10 categories, resembles the "Southeastern Europe Countries Framework List", which was prepared by a wide group (Theodossiou-Drandaki et al., 2004). However, the following Geosite Framework List for Turkey is not identical to the one suggested for the Southeastern Europe Countries (the Balkans) (Theodossiou-Drandaki et al., 2004). The difference is estimated to be ca 30% (Table 1).

One of the purposes that lay behind creating the FL is to be able to choose representative geosites and geological heritage on the scale of the country, region, continent, and world in the future. For example, every country in a continent may choose the best C-T transition sedimentary sequence, and then it will be possible to determine the most typical one within the continent and finally to determine the perfect C-T sedimentary sequence of the world. If many perfect examples exist, their promotion will be continued by choosing, for example, the "Seven Wonders of the World" decennially, as is done within the implementation of World Cultural Heritage.

As mentioned in the previous paragraph, during the preparation of the proposed FL, the Balkan FL was taken into consideration. It was necessary to add a number of new titles (frameworks) because of the high geological diversity in Turkey, such as "extensional volcanism in the Plio-Quaternary", "transform fault volcanism", "local natural building stones", and so on (Table 1). The proposed List brings the following limitations (Figure 2).

The FL should be evaluated as a whole because some titles may be included in two or more categories. They are listed under the closest category so as to prevent repetitions and convergences.

Attention was paid to making the titles (Framework) focus on given subjects. In order to do so, we had to give some sub-titles in parentheses, for example, "Marine Coastal Deposits (ooids, beachrocks, terraces, sand bars)" (Table 1). The main context of that framework is that formations occurred on coastline depending on sea level changes. Such a grouping is necessary, otherwise innumerable variations may come into existence and the FL will become useless (ProGEO Group, 1998; Brilha et al., 2005).

When examining a FL, what should be considered seriously is that while geosites (and therefore the geosites inventory) are concrete, observable, and tactile objects, the framework and the FL describe the events and processes in the geological past (Figure 1). Even if there are similarities between geosites' names and frameworks, they are actually intended to describe the processes. An ideal FL should include all events and phases of the geological evolution of the country. The FL proposed here is not ideal, of course; however it should cover the principal geological events in the country, at least. To achieve it, we tried to choose individual frameworks which represent relatively wide time intervals (Table 1).

No "framework" could be formed in *Group g* (Astroblems) and *Group i* (Submarine), as there are no suggested geosites in the JEMIRKO inventory. Nevertheless, it was thought that it would be beneficial for the future to at least retain the group names. Similarly, it cannot be said that there are many geosites to be included under every title (framework) suggested here. However, the presence of the geological occurrences relevant to these titles is known from the literature. It is expected that earth scientists will contribute and overcome the deficiencies of the proposed list.

Table 1- The proposed "Geosite Framework List for Turkey"

Group a) STRATIGRAPHIC

a1) Quaternary

Marine coastal deposits (ooids, beachrocks, terraces, sand bars)
Pleistocene caliches and calcretes

a2) Phanerozoic

Late Neogene (Pliocene) marine deposits
Neogene evaporite basins
Parathetis successions
Marine and continental Miocene molasse
Complete marine cycles of Neogene
Tertiary mammalian beds
Extensive transgressions in Late Tertiary
Palaeogene basins
Paleogene bioherms
Reference stratigraphic sections of Palaeogene stages
Sedimentary and biological characteristics of time-boundaries
Late Cretaceous-Palaeocene carbonates
Late Cretaceous reefs
Mesozoic carbonate platform
Mesozoic platform deposits of Neothetis
Jurassic-Cretaceous deep marine facies
Ammonitico Rosso facies
Triassic-Jurassic carbonate successions
Late Triassic rift volcanisms related to the opening of Neothetis Ocean
Rift deposits related to the opening of Neothetis Ocean
Hersinian molasses
Marine and continental deposits of Carboniferous
Lower Palaeozoic succession of northern Gondwana
Cambrian sedimentary sequence

a3) Proterozoic

Precambrian rocks

Group b) PALAEOENVIRONMENTAL

Trace fossils
Paleokarsts
Foot prints on volcanites
Mammalia beds with hominoid and handcrafts
Fish and leaf fossils
Neogene paleosols
Neogene siliceous trees
Miocene bivalves
Large Tertiary foraminiferas
Bouma turbidite sequences
Incised valleys
Cretaceous ammonites
Devonian fishes
Euxinic environments of Early Silurian
Ordovician and Silurian Graptolites

Group c) VOLCANIC, METAMORPHIC AND SEDIMENTARY PETROLOGY, TEXTURES AND STRUCTURES, EVENTS AND PROVINCES

- Collision volcanisms of Quaternary
- Extension volcanisms of Plio-Quaternary
- Volcanic landforms (Calderas, Maars,Tuff rings)
- Bazalt flows and columnar basalts
- Pyroclastic flows and ignimbrites
- Neogene rift volcanisms
- Stratovolcanoes
- Transform-fault volcanisms
- Continental arc volcanisms of Cretaceous
- Neothetis suture zone
- Neothetis island-arc complex
- Neothetis oceanic crust series
- Sanidinite facies of contact metamorphisms
- Eclogite and blue-schist facies
- Triassic high-pressure metamorphism
- Oceanic crust on the Palaeothetis subduction zone
- High pressure Alpine metamorphisms
- Products of high-grade metamorphism
- Core complex in massives
- Precambrian ophiolites and island arcs
- Nappes and ophiolite complexes

Group d) MINERALOGICAL, ECONOMICAL

- Neogene evaporitic mineral beds (trona, borax, soelestine)
- Type localities of minerals Konyaite, Bursaite and Pandermite etc
- Lacustrine Sepiolite formations
- Metamorphic and sedimentary bauxites
- Thermal spring carbonates
- Valuable stones and gemological minerals

Group e) STRUCTURAL

- Seismically active normal and transform faults
- Tectonic creeps
- Structural landforms
- Tectonically active basins (grabens, pull-aparts)

Group f) GEOMORPHOLOGICAL FEATURES, EROSIONAL AND DEPOSITIONAL PROCESSES, LANDFORMS AND LANDSCAPES

- Recent eolian sand dunes
- Evaporite karsts
- Modern lakes, wetlands and rivers
- Modern marine coastal landforms (spits, bars, beaches, lagoons, deltas)
- Karstic landforms (obruks, sinkholes, dolins, polje, caves)
- Glacial landforms and deposits
- Canyons and valleys
- Erosional landscapes
- Volcanic landscapes

Group g) ASTROBLEMS
Group H- CONTINENTAL OR OCEANIC SCALE GEOLOGICAL FEATURES, PLATE RELATIONSHIPS Foreland trust belt of Afro-Arabian plate
Group i) SUBMARINE
Group j) HISTORICAL AND CULTURAL Antique marble and ore mines The sites where the geological terms firstly defined Local and specific building stones

5. Discussion and Conclusions

The FL presented in this study is a suggestion formed by the authors using their own experiences and comments of some eminent colleagues (Table 1). It is open to all contributions. The aim of the study (FL) is to act collaboratively with the worldwide geological community and to increase the impacts of internal researches on the literature. For example, publications that refer to titles in the FL will be followed more widely.

It should be re-emphasized that the Geosite Group (Category), Geosite FL, and Geosite Inventory are entirely different concepts, even though they are interrelated (Figure 1). Eighty-five titles (frameworks) are suggested in the present list. Most of them are found in *Groups a and c*. This means that the majority of the framework is related to stratigraphic, tectonic, and magmatic events. That is usual as the geological evolution itself occurs through these three processes. No explanation about the individual titles (frameworks) could be provided here, even in brief, as it would exceed the limits of this paper. Detailed analyses and explanations of the FLs are needed and hopefully they will be released soon by Turkish earth scientists.

One of the common results of the studies on geosites, geological heritage, the Geosite FL, and geoparks shows that all natural occurrences represent geodiversity; relevant topics and disciplines are not in competition but support each other. For instance, in the FL, all events from the Holocene to the Precambrian have to be studied by a similar methodology. The competitive atmosphere between geography and geology, geology and geophysics, hydrology and climatology, and ecology and geography seemed to be changed to a quarrel which was started once time and is still continued by some people, has not helped us to understand nature, and, moreover it has had negative effects on the development of earth sciences in the country. It is known now that walls have collapsed between disciplines and they can cooperate or learn from each other.

Another result from the geosite and FL studies is that the urgent need for geological conservation in our country has unfortunately increased to a dramatic level (Kazancı et al., 2005; 2012). Constructions, particularly larger ones, seem to be a primary threat to geosites all over the country; however, our unofficial survey showed that most of the damage has originated from the lack of public awareness of geosites. The gradually increasing interest of local administrations in geoparks and geotourism could serve geoconservation if people are informed successfully. The responsibility for this subject belongs to earth scientists.

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