Earth-Science Reviews 185 (2018) 624–648

Contents lists available at ScienceDirect

Earth-Science Reviews

journal homepage: www.elsevier.com/locate/earscirev

Provenance of Mesozoic to Cenozoic circum-Mediterranean sandstones in relation to tectonic setting

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ARTICLE INFO

Keywords:
Circum-Mediterranean Orogens
Sandstone detrital modes
Provenance analysis
Paleogeography
Paleotectonic evolution

ABSTRACT

The composition and stratigraphic relations of clastic strata in diverse sedimentary basins of the circum-Mediterranean region reflect a complete record of provenance relations since break-up of Pangea, neo-Tethyan taphrogenesis, and subsequent plate convergence between the two major plates of Europe and Africa, and other related microplates of Iberia, Adria, Mesomediterranean, and toward to the eastern Mediterranean, the Anatolian microplate.

Since plate reorganization after the breakup of Pangea, at the end of Paleozoic-earliest Mesozoic, clastic wedges filled sedimentary basins within geodynamic settings evolving from intracontinental rifts, rifted-continental margins, protoceanic basins, arc-trench basin-systems, remnant ocean basins, foreland basin systems and intramontane and back-arc basins within the circum-Mediterranean region.

The changing nature of clastic particles in these clastic wedges reflect the provenance relations from different source rocks within the spatial and temporal evolving geo-puzzle terranes, including relations between ophiolite-bearing, uplifted continental crust (both shallow to deep crust terranes), volcanic and sedimentary (particularly carbonate strata) source rocks.

Mixed siliciclastic and carbonate shallow- to deep-marine clastic wedges are diffuse in many filled basin systems along the Mediterranean, as such as occurrence of volcaniclastic layers interbedded with siliciclastic wedges.

The variable mosaic of source terranes within the Mediterranean region, offered the possibility to investigate provenance relations with a new plane of precision and sophistication, discriminating grain particles in clastic wedges using spatial (extrabasinal versus intrabasinal) and temporal (coeval versus noncoeval) distinction of detrital signals. The spatial/temporal approach in deciphering particles in clastic rocks has been widely used to detail the basinal dispersal pathways in different geotectonic settings, wherever mixed silicate and carbonate terranes act as the major source rocks, from rifted-continental margins to collisional orogens.

1. Introduction

The circum-Mediterranean belt is largely debated in terms of geodynamic evolution, timing of deformations, and plate circuit reconstructions, that is mainly related to the multiple phases of closure of branches of the Tethys Ocean basin (e.g. Guerrera et al., 1993; Perrone et al., 2006; Critelli et al., 2008; Guerrera et al., 2005; Hosseinpour et al., 2016, and bibliography therein). The circum-Mediterranean belt evolved throughout the Mesozoic and into the Cenozoic within the area bounded by Mediterranean margins of Eurasia and Africa. The region (Fig. 1) is mainly dominated by the evolution of the Tethys Ocean system, occupying the region between Eurasia and Africa, characterized by multiple phases of rifting, seafloor spreading, subduction, and collision. Only small fragments of oceanic crust formed within the Tethys Ocean are believed to be preserved in situ (Speranza et al., 2012), while remnants of its closure can be found in the Pyrenees, Alpine, and Carpathians orogenic belts in the north, the Anatolian plate in the east, and the northwestern coast of Arabia and Atlas Mountains in the south (e.g. Hosseinpour et al., 2016, and bibliography therein).

The most characteristic expressions of circum-Mediterranean tectonism are foreland basin systems that mark orogenic belts that stand parallel with them. These orogenic systems are mainly related to the multiple phases of closure of branches of the Tethys Ocean basin, defining (i) north-vergent orogenic systems, as the Alps and Betic Cordillera, related to closure of the western branch of the Tethys Ocean (Ligurian-Piedmont-Nevadofilabride oceanic realm), and (ii) southern

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https://doi.org/10.1016/j.earscirev.2018.07.001
Received 29 March 2018; Received in revised form 5 July 2018; Accepted 5 July 2018

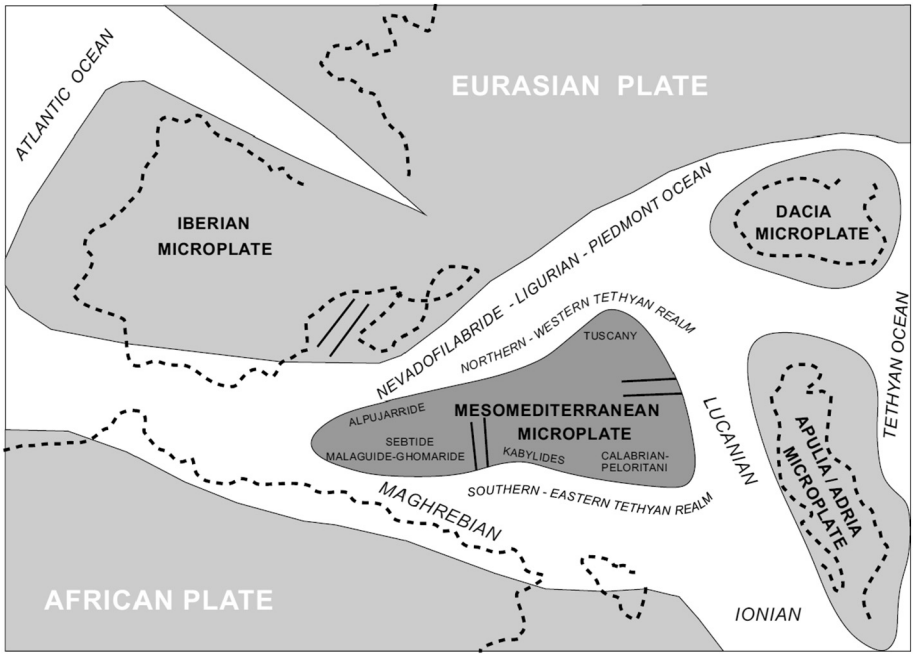

Fig. 1. Location of tectonic features in the Western Tethys and surrounding areas showing the position of the Mesomediterranean Microplate and related other plates. Modified from Perri et al. (2017).

and northeastern-vergence orogenic systems, as northern Africa orogen (Rif and Tell belts) and Apennines, related to closure of the eastern/southern branch of the Tethys Ocean (Maghrebide Flysch Basin, Lucanian and Ionian oceanic realm) (Fig. 1).

Ancient sedimentary basins preserved within the circum-Mediterranean belt, are thick sedimentary sequences that record the tectonic evolution of the region since breakup of Pangea, from Tethyan Rifting, to consume Tethyan oceanic plate and related accretionary orogenic system. Mesozoic to Tertiary sedimentary strata are clastic, pelagic and carbonate dominantly. Clastic strata are well preserved in all the tectonic evolution of the circum-Mediterranean belt from supercontinent breakup to continental accretionary processes.

This paper discusses detrital modes of sandstones in ancient sedimentary basins that are exposed in the circum-Mediterranean belt, discussing and combining previously published data with new fresh data. The sandstone compositions are fully compatible with derivation from sources within the circum-Mediterranean orogenic belt, defining intriguing provenance relations from recycled orogenic provenance, uplifted continental block provenance, cratonic provenance, and interbedded minor contribution from active magmatic arcs. These tectonic provenance terranes defines distinctive sandstone suites or mixed petrofacies. Provenance interpretations are essential to reconstruction and testing of paleogeographic and paleotectonic models. The general significance here is that the complex tectonic history of the circum-Mediterranean orogen can benefit from the application of petrographic provenance analysis as a test of alternative tectonic scenarios, that can be useful for analysis of sediment dispersal systems on a global scale of other major orogens.

2. Data presentation and petrological parameters

Most circum-Mediterranean sandstones that have been used in detail are of early-middle Mesozoic (upper Triassic-earliest Jurassic) to Cenozoic age.

Sandstone compositions are reported here as mean detrital modes of selected suites in the format adopted to decipher and subdivide the suites for their tectonic provenances and types of sedimentary basins. Data set includes a review of both revised of previously published data integrated with fresh data. Table 1 lists the mean detrital modes of all available data subdivided for the key tectonic history of the circum-Mediterranean belt in terms of types of sedimentary basins, the subdivision of the Tethyan oceanic realms (western vs. eastern and southern realms), geographic location of circum-Mediterranean thrust belts, and for some typical provenance terranes (i.e., cratonic provenance, magmatic-arc provenance). Data base consists of 63 sandstone suites made up of about 2235 individual samples for which point counts are reported in 56 different references.

The modal sandstone composition is determined by point-counting using the Gazzi-Dickinson method (Ingersoll et al., 1984; Zuffa, 1985, 1987). The framework grain types that are used for discussions of detrital modes are those of Dickinson (1970, 1985), Zuffa (1985, 1987), Critelli and Le Pera (1994), and Critelli and Ingersoll (1995) and comprise:

a) Quartz grains, including monocrystalline quartz grains (Qm), and polycrystalline quartzose lithic fragments (Qp), and total quartzose grains (Qt = Qm + Qp);
b) Feldspar grains (F), including both plagioclase (P) and potassium feldspar (K);
c) Aphanitic lithic fragments (L), as the sum of volcanic and metavolcanic (Lv and Lvm), sedimentary (Ls) and metasedimentary (Lm; including Lsm as the sum of Ls + Lm). Ls includes here also carbonate lithic fragments (extrabasinal carbonate grains of Zuffa, 1980, 1985; Critelli et al., 1990a, 2007), because of their importance and occurrence in detrital modes of Apenninic sandstones;
d) phaneritic + aphanitic rock/lithic fragments (R), recalculated by point-counting of specific assignment of aphanitic Lm, Lv and Ls lithic fragments plus quartz, feldspar, micas and dense minerals in polimineralic fragments in which these minerals individually are larger than the lower limit of the sand range (0.0625 mm), that during counting are summed as quartz (Qm) and feldspar (F) or micas or dense mineral grains (e.g., Ingersoll et al., 1984; Zuffa, 1985, 1987; Critelli and Le Pera, 1994; Critelli and Ingersoll, 1995).

For diagrams, the proportions of quartzose grains, feldspar grains and aphanitic lithic fragments are recalculated to 100%, and summary