The Morphology and Masses of EROs in the Groth Strip

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We present our results on the morphologies, masses and possible correlations between the two properties of 108 extremely red galaxies (EROs) found in the Groth strip. The photometric data include $UBV_{F606W}I_{F814W}JK_s$. The EROs were selected on the basis of their extremely red colour I_{F814W}-$K_s \geq 4$. Morphologies are based on a by eye classification and we distinguish between 3 basic classes: compact objects, targets with a bulge and/or disc component and irregular/merger candidates (**Fig. 1**).

Mass estimates were obtained by a best-fit model approach, assuming an exponential declining star formation rate with a wide set of parameters, e.g. decay time, redshift of formation, metallicity and optical depth.

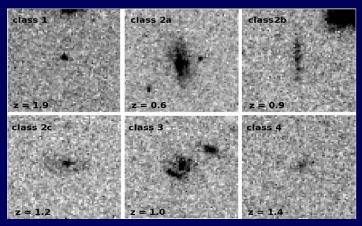


Fig.1: HST/WFPC2 F814W images of an ERO of each morphological class.

The total stellar mass and age of each ERO was determined by selecting the model with the lowest χ^2 as best-fit model. However, this procedure is not straight forward, since various models have similar χ^2. **Fig. 3** shows an example: the upper left plot shows the models with the lower χ^2, the black region marks all solutions those χ^2 is less than 20 greater than the best-fit solution.

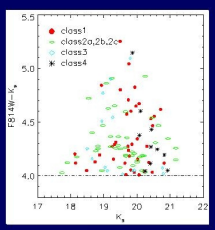


Fig.2: CMD for all 108 EROs. Objects we were not able to clearly classify are found at fainter magnitudes.

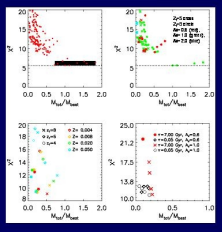


Fig.3: Variation of χ^2 as result of template fitting. The dotted line represents the minimal χ^2.

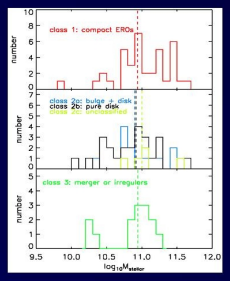


Fig. 4 Distribution of total stellar mass. The vertical lines show the median of each distribution.

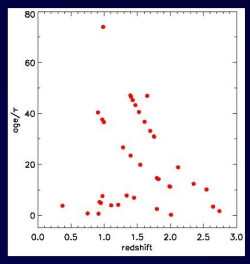
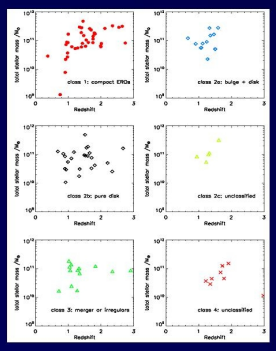


Fig. 5 Ratio between $t(z_f)$-$t(z)$ / τ for EROs with compact morphology.



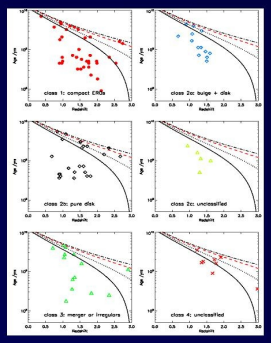


Fig. 6: Total stellar mass a for the morphological classes. The lines in the right panel show the maximal possible age for z_f=3, 4, 6, 8, from bottom to top.

Compact EROs:
- modelled with SFR$\propto$ SFR(z_f)*exp(-t/τ), 26 of 39 EROs have $\tau \leq 100$ Mio years,
- some examples with long decay-times
- Deficiency of low mass objects at higher redshifts is result of limited depth (**Fig.6, left**)

EROs with bulge and/or disc:
- older than 1Gyr, but star formation started later than z_f =4
- almost constant mass in whole redshift range

Merger/irregular EROs:
- in none of these objects started the last episode of star formation later than z_f=4,
- 6/13 have populations younger than 1Gyr

Unclassified EROs:
- lowest masses and older than 1Gyr

Results:

From the visual classification of our ERO sample we find that:
- 37% ± 6% of EROs have compact morphology
- 40% ± 6% have a disc component
- 13% ± 3% seem to be either irregular or merging galaxies
- 10% ± 3% could not be classified

The most secure classification of our sample has been obtained for the compact class. The classification for EROs in class 2c and 4 is the least reliable, no object in either class shows a distinct morphology.

Fig.2 Shows the distribution of the different morphological classes on the colour-magnitude plane. All morphological classes are found at all magnitudes, but most of the faint objects with irregular or merger characteristics have less red colours then their brighter counterparts. Brighter EROs ($K \leq 19.5$) are slightly dominated by disc-like morphologies.

Considering that the mass estimates can vary by factors of 2 and more, we find no dependency of median stellar mass on the morphological type of our ERO sample (**Fig. 4**).

The age and mass distribution are not strictly consistent with our expectations from the morphological studies. We find a number of EROs with compact morphologies **AND** extended star formation. In addition, EROs with clear discs, supposedly star forming systems, have ages of 1Gyr and older.

The majority of merger candidates and irregular galaxies contains considerable amounts of stellar mass, ~$10^{11} M_{\odot}$.

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Our results will be published asap.

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